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PHILOSOPHICAL PRINCIPLES OF Natural Religion:

Containing the

ELEMENTS

OF

Natural Philoſophy,

And the PROOFS for

NATURAL RELIGION,

Ariſing from them.

By GEORGE CHEYNE, M. D. and F. R. S.

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The Right Honourable

JOHN,

EARL of *ROXBURGH*,

Lord *Ker*, *Ceſsford*, and *Cavertoun*, &c.

Principal Secretary of State for the Kingdom of *Scotland*.

My Lord,

THE following Treatiſe may in ſome Meaſure, claim the Honour of Your Lordſhip's Patronage, as being undertaken in Obedience to Your Commands, and con-

taining part of thoſe Diſcourſes, I had with your Lordſhip, when you allow'd me the Honour, to talk with you on Philoſophical Subjects; *Tho' Your Lordſhip's uncommon Advances, even in the more abſtruſe parts of* Geometry, *and* Natural Knowledge, *have made you ſo great a* Maſter *of Reaſonings of this kind, that I am not capable of offering any thing to You worthy Your own Peruſal; yet did but the Performance, anſwer the Dignity of the Subject, I ſhou'd not think it, unworthy of Your Lordſhip's Protection.*

Such has been Your Lordſhip's happy Genius, *and* Conduct *in Your Studies, that Your great Progreſs in the nobler parts of* Philoſophy, *has not retarded Your deep Inquiries, in the Knowledge of* civil Government; *nor Your* univerſal Learning *rendred you more unfit for an active Life, and doing good to Mankind. It was the peculiar Wiſdom of the* Antients, *to lay ſuch Foundations both for* Knowledge, *and for* Buſineſs, *that they left it to their Stars to determine, which of the two ſhou'd afford them Occaſion, to become moſt uſeful to Mankind. What*

Proviſion Your Lordſhip has laid in for the firſt, if others know not as I do, it is becauſe they have not had Occaſion to Diſcourſe with You on Subjects of Learning. And the Queen's Choice, is an undoubted Proof of Your Capacity for the other. Her Majeſty having put You, in the moſt difficult Poſt of the Government of Your Country, I wou'd ſay too, in the moſt difficult Times, if any thing could be reckon'd ſo, for the preſent Reign.

It was Your Lordſhip's Opinion, that the Providence of the Almighty Governour of the Univerſe, *had reſerv'd to this*

this laſt Age, thoſe great Advantages, by which the Secrets of Nature have been more happily unravell'd, than in any former Times, on purpoſe, to expoſe the Folly of a corrupt Generation of Men, who from their vitious Practices, being prone to Atheiſm, *have vainly pretended, the* Oracles of Reaſon *to be on their ſide. And upon the ſame account, I cannot but look upon Your Lordſhip as a ſingular* Bleſſing, *as well as an* Ornament *to Your Country, who are a* Living Exemple, *that true* Knowledge, *and* Probity *go Hand in Hand, and that* Greatneſs *and* Honeſty *receive* *additional* Luſtre *from one another. But, becauſe I would not offend Your Lordſhip's darling Vertue, Your* Modeſty, *I ſhall chooſe to tranſgreſs againſt the common Rules of Dedications, and ſhall not preſume, to mention, either Your* Birth, *or* Fortune, *or* Breeding, *or* Temper, *or which is more valuable, that* Probity *and* Candor *that ſhines in all You ſay or do, but ſhall only make good Wiſhes, ſupply the Place of a juſt* Encomium.

May Your Lordſhip be as happy in your Adminiſtration, as the Motives upon which you *accepted it, were Juſt and Honourable. May you be as eaſie in your Office, as you are to all the World in your* Temper. *And as your noble Mind, has ſecur'd you from mean and narrow Prejudices; May your Integrity protect you from unjuſt Malice; May your Endeavours for ſettling the Peace and Happineſs of your Country, be as ſucceſsful, as your Love to it is ſincere.*

Theſe, my Lord, are the only Returns, I can make your Lordſhip, for the many Favours I have receiv'd from you, and this ſmall Treatiſe *is the only*

Preſent I have to offer you; of which however, I beg your Lordſhip's Acceptance, and that your Lordſhip wou'd believe, that no one can Honour you more, than

My Lord,

Your Lordſhip's

moſt humble, and

moſt obliged Servant,

GEO. CHEYNE.

THE PREFACE.

THE End and Deſign of theſe Diſcourſes, may be gathered from the *Title Page*, and the *Contents*; and I have already hinted, what gave the Occaſion and Riſe to them, *viz.* the Commands and Converſation of that *noble Perſon*, to whom they are inſcribed. As for the Materials, ſome of them I borrowed from the Works of thoſe Learned Men, I have had Occaſion to be converſant in; others I had, by a little reflexion on my Subject. If any one think, I have made free with their Inventions, without doing Juſtice to their *Names*, I give every Man Liberty to lay in his own Claim, and aſſert his juſt Right, for I induſtriouſly avoided all Quotations, becauſe my Subject wanted not *Authorities*, but *Demonſtration.* Some part of the Matter was furniſhed me from Mr. *Newton*'s Store, and his Inventions have ſuch peculiar Marks, as will diſtinguiſh them, even in my rude Dreſs, without particular *Innuendo's*. For what concern'd the *Animal Oeconomy*, beſides, *Borelli* and *Bellini*, that *Friend* to Mankind, my conſtant good Friend, Dr. *Archibald Pitcairn* his *Diſſertations* ſupply'd me the moſt plentifully. I borrowed but little, from thoſe who have written on the ſame Subjects with my ſelf, both to avoid Repetitions, and becauſe they generally went on Principles (tho' juſt and demonſtrative) yet of a different Nature from mine.

If I have had the Misfortune, to differ in ſome few *Philoſophical* points, from ſome great and deſerving Men; I hope they will have the Goodneſs to pardon me, having treated their Opinions, with all the *Candor* and *Regard* due to their *Merits*, without mentioning their *Names*; and a *mannerly* Liberty in *Philoſophical* points, is allow'd to ev'ry Body.

That theſe Sheets have not many more Faults than they have, is owing to the Judicious Corrections and Advices, of the *Reverend* and *Excellent Mr. John Craig*, and the Learned, *Dr. Arbuthnott Phyſician to his Royal Highneſs*, and Dr. *Friend* of *Chriſt-Church Oxford.* Men ſufficiently eminent in the Common-Wealth of Learning, not to want any Paneygrick from me.

If I am not over fond of my Subject, I think I may ſay, a Treatiſe on it was wanted, I wiſh there may not be Occaſion of ſaying ſo ſtill. If my Performance excite others, of more Leiſure and Capacity to do it the Juſtice it deſerves, I have obtain'd the end of my Ambition.

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THE *Philoſophical Principles* OF NATURAL RELIGION.

CHAP. I.

Of the Phyſical LAWS, *and the Uniform Appearances of* NATURE.

§ I. THERE is nothing a more common Subject of Diſcourſe than *Nature* and its *Laws*; and yet, however Uſe has made theſe Words familiar, there are few that agree in their Notions about them: The Reaſon of which ſeems to be, that theſe Terms imply *Notions* ſo compounded, and ſo far remov'd from the Knowledge of moſt Men, that there are ſcarce any that diſtinctly conceive all the Simple *Ideas* that enter their Compoſition; I ſhall not pretend to ſettle the Signification of theſe Words in their utmoſt extent; it will be enough to my preſent purpoſe, to give the Senſe I ſhall apply to them in the following Diſcourſe.

§ II. By *Nature*, I underſtand this vaſt, if not infinite *Machin* of the *Univerſe*, the Perfect and Wiſe Production of Almighty God, conſiſting of an infinite Number of leſſer *Machins*, every one of which is adjuſted by Weight and Meaſure. By the *Laws of Nature*, I mean, thoſe Laws of Motion by which natural Bodies are govern'd in all their Actions upon one another, and which they inviolably obſerve in all the Changes that happen in the natural State of things. But here we are to diſtinguiſh between the Laws of *Creation* and thoſe of *Nature*, for not only the great Bodies of this Univerſe, but the inferiour *Machins* thereof, were created by a different Law from what they are now govern'd, as ſhall afterwards be more fully explain'd.

§ III. That there is no ſuch thing as an *Univerſal Soul* animating this vaſt Syſtem according to *Plato*, nor any *Subſtantial Forms* according to *Ariſtotle*, nor any Omniſcient *Radical Heat* according to *Hippocrates*, nor any *Plaſtick Virtue* according to *Scaliger*, nor any *Hylarchic Principle* according to *Henry More*, is evident from the following Conſiderations; 1. Theſe are meer *Allegorical* Terms coin'd on purpoſe to conceal their Author's Ignorance. When the *Philoſophers* cou'd not account for the appearances of Nature, they were ſo far from owning any want of Knowledge, that to keep up their Credit with the thoughtleſs and credulous part of Mankind, they attributed theſe unaccountable Effects to unintelligible Beings of their own Contrivance, which neither had Foundation nor Exiſtence in Nature: But whoever will give themſelves the leaſt trouble to conſider the Matter, will plainly ſee, that they really meant nothing by thoſe amazing Terms, but to diſguiſe their own Ignorance. 2. Theſe Beings are derogatory from the Wiſdom and Power of the *Author* of *Nature*, who doubtleſs can govern this *Machin* he cou'd create, by more direct and eaſie Methods, than employing theſe ſubſervient *Divinities*. 3. The Appearances themſelves, to ſalve which they were contriv'd, may be by more intelligible and leſs indirect Principles accounted for, as in ſome meaſure ſhall be afterwards ſhown. 4. Laſtly, Theſe very *Beings* will not ſerve the deſign of their Creation, unleſs we endow 'em with Powers and Faculties above the Dignity of ſuch ſecondary Agents.

§ IV. The *Scheme* of *Nature* which ſeems moſt agreeable to the Wiſdom of its Author, is (ſuppoſing the *Syſtem of the Univerſe* already created) that he has ſettled Laws, and laid down Rules, conformable to which, Natural Bodies are govern'd in their Actions upon one another, and according to which, the Changes in the material part of this *Syſtem* are brought about which all Bodies inviolably obſerve, and which of themſelves naturally acting, they never tranſgreſs in the leaſt degree, whilſt *God Almighty* preſerves them in their Faculties and Operations. This Great *Machin* of the *Univerſe*, may in ſome degree be liken'd to a finiſh'd Piece of Clock-Work, form'd upon *Geometrick* Principles, which naturally, and of it ſelf (as long as the Parts are kept together) will go on in the ſame conſtant tenour of Motion, unleſs diſturb'd by ſome external Force; the Movements of this Clock-Work depend upon thoſe General Rules, according to which, one Part communicates its Motion to another, and are particularly determin'd by the Configuration of the ſeveral Pieces of which it conſiſts. I ſhall not here conſider the Actions of Beings, that have a Power of *Free-Will*, nor even of thoſe that have *Self-Motion*, ſuch as are all Animal Agents; nor do I in the leaſt degree exclude the Government of *God Almighty* in this World. On the contrary, my principal Deſign is to demonſtrate his continued Providence from evident Principles, and to convince the World, that he not only has the Springs of this *Great Machin*, and of its ſeveral Parts in his own Hand, and is the firſt *Mover*; but that without his continual Influence and Support, the whole Movement would ſoon fall to Pieces. Beſides this, he has reſerv'd to himſelf the Power of Diſpenſing with theſe Laws, when he pleaſes.

§ V. It is not my Deſign here to explain all the particular *Laws of Motion*, and of the Actions of Bodies upon one another, nor cou'd it be well done in ſo narrow a Compaſs as I have propoſed to my ſelf, I ſhall here only ſet down the General *Laws of Nature*, which virtually include theſe others, and infer ſuch Concluſions from 'em as I find moſt neceſſary for cleaing ſome parts of the following Diſcourſes.

LAW I.

ALL Bodies perſevere in the ſame State of reſt, or of moving forward in a ſtrait Line, unleſs forc'd out of that State by ſome outward impreſs'd Violence *i. e.* all Bodies at reſt will naturally, and of themſelves for ever continue in reſt, unleſs ſome external Cauſe put 'em in Motion: And all Bodies in motion will naturally move forwards for ever in the ſame ſtrait Line, unleſs they are ſtop'd by ſome oppoſite Force, or turn'd out of their Courſe by ſome differently directed Violence.

§ VI. To ſhew how inviolably this Law is obſerv'd by natural Agents, we need only conſider it never has been obſerv'd that any Body did of it ſelf, bring it ſelf from Reſt to Motion, nor that ever any Body in Motion, brought it ſelf to Reſt; Nor that ever any Body in Motion, of it ſelf altered its Courſe, but that where ever ſuch Changes happened, there were always evident Cauſes. If Bodies chang'd their places of themſelves, all Things wou'd run into Confuſion, nor wou'd there be any certain Laws to regulate the *Motions* of the Univerſe. We are certain *Projectils* wou'd for ever move on, in the ſame right Line, did not the Air, their own Gravity, or the Ruggedneſs of the Plane, on which they move, ſtop their Motion; or did not ſome Body with a different Direction alter their Courſe. A Top whoſe parts, by their Coheſion, hinder one anothers rectilinear Motions, wou'd never ceaſe to turn round did not the Air, gradually impair its Motion. Natural Bodies conſiſt of a Maſs of Matter, which by it ſelf can never alter its State, and if Bodies are once at reſt, they muſt continue ſo, unleſs ſome new Force put 'em in Motion. If in Motion, the ſame Energy will continue 'em in Motion and drive 'em forwards in the ſame Directions.

§ VII. Moreover, there is in Matter an unactive *Principle*, which Mr. *Newton* very well expreſſes by the *vis inertiæ*, whereby Bodies reſiſt to the utmoſt of their Power, any change or alteration of their State, whatever it be, either of Reſt, Motion, or its Direction; And this Reſiſtance is always equal in the ſame Body, and in different Bodies is proportional to the quantity of Matter they contain. There is required as much Force to ſtop a Body in Motion, as is required to put it in Motion, and *è contrà*; And therefore ſince the ſame Body equally reſiſts the contrary equal Changes of its State, this Reſiſtance will operate as powerfully to keep a Body in Motion as to keep it at Reſt, and conſequently of it ſelf, it can never change its State of Reſt, Motion, or Direction; for to change its Direction, is the ſame thing as to move of it ſelf another way. Matter then of it ſelf is ſo far indifferent to Motion or Reſt, that it is no more inclin'd to the one than to the other, and does no leſs Reſiſt a change from Reſt to Motion, than from Motion to Reſt. This *vis inertiæ* is no where more conſpicuous than in the ſudden Motion of a Veſſel full of Liquor upon a Horizontal Plane, at firſt the Liquor ſeems to move with a Direction contrary to that of the Veſſel, not that there is really any ſuch Motion impreſs'd upon the Liquor, but that the *vis inertiæ* endeavouring to continue it in its State of Reſt, the Veſſel can't immediately communicate its Motion to the Liquor; But the Liquor perſeveres in its State of Reſt whilſt the Veſſel makes forward and ſo ſeems to move a contrary way. But when once the Liquor has the Motion of the Veſſel communicated to it, and begins to move with a velocity equal to that of the Veſſel, if the Veſſel be ſuddenly ſtop'd, the Liquor continues its Motion and daſhes over the ſides of the Veſſel.

Corollary 1.

§ VIII. Hence it is evident that no Particle of Matter, nor any Combination of Particles, *i. e.* no Body, can either move of themſelves, or of themſelves alter the Direction of their Motion; Matter is not endow'd with Self-motion, nor with a Power to alter the Courſe in which it is put, it is meerly paſſive and muſt for ever of it ſelf continue in that State and that Courſe that it is ſettled in; and indeed, if it can't move of it ſelf, it can never alter its Courſe of it ſelf when in Motion, for to alter its Courſe of it ſelf is only to move of it ſelf after a particular manner.

Corollary 2.

§ IX. Hence it is Evident, that no Body put in Motion will naturally, and of it ſelf move in a *Curve Line.* All Motion is naturally forward in the ſame ſtrait Line with the Direction of the moving Force;

but what ever moves in a Curve Line muſt in every Point alter its Direction, and therefore naturally of it ſelf, no body can move in a *Curve Line.*

Corollary 3.

§ X. Hence the great Bodies of this Univerſe the *Planets*, their *Satellits* and the *Comets* do not naturally and of themſelves (tho' at firſt put in Motion) move in their repective Orbits, which are *Curve-Lines* returning into themſelves, but are kept in by ſome attractive Force. which if once ſuſpended they wou'd for ever run out in right Lines, and conſequently the Motions of theſe Great Bodies in their *Orbits* do abſolutely depend upon this attractive Force, whenceſoever it ariſes.

Corollary 4.

§ XI. Hence neither Motion nor Reſt (I mean not one of 'em particularly) is eſſential to Matter. *i. e.* Matter is indifferent as to either of theſe particularly, and does as much reſiſt its being chang'd from Reſt to Motion, as it does the being chang'd from Motion to Reſt. And as any Force will imprint ſome degree of Motion on a quieſcent Body, ſo the ſame degree of Force impreſs'd at the ſame time with a contrary Direction, will bring it to Reſt again, but it is not neceſſary to the *Being* of Matter; that it be in Reſt or Motion, for Matter will be ſtill Matter in which ever of theſe States it be.

Corollary 5.

§ XII. Since then it is not eſſential to Matter to be either in Reſt or in Motion, it is evident that the preſervation of a Body in Reſt or in Motion (after the firſt Inſtant) does abſolutely depend upon *Almighty God* as its Cauſe, no part of Matter can move it ſelf, nor when put in Motion, is this Motion abſolutely eſſential to its being nor does depend upon it ſelf, and therefore the preſervation of this Motion muſt depend upon ſome other Cauſe, but there is no other Cauſe aſſignable, but that Omnipotent Cauſe of the preſervation of the Being and Faculties of all natural Agents. Now this Corollary does in no manner interfere with the preceding Law, as perhaps ſome may think, for by that Law, the inability in Matter (ariſing from its *vis inertiæ*) to change its State of Motion, Reſt, or Direction is declared, whereas by this Corollary, the immediate Cauſe of this *vis inertiæ* is referr'd to, *viz.* the Influence of the Divine Power, for though by this *vis*, Bodies perſevere in their State of Motion, Reſt and Direction, yet this *vis* is not eſſential to Matter, but a poſitive Faculty implanted therein by the Author of Nature, as ſhall be afterwards more fully explain'd.

Corollary 6.

§ XIII. Hence the Neceſſity of a *vacuum*, or ſpace diſtinct from Matter, is clearly demonſtrable; for ſince by their *vis inertiæ*, all Bodies reſiſt to the utmoſt of their Power, any Change or Alteration of their State, whether of Motion or Reſt. And ſince the Reſiſtance in the ſame Body is always equal, or the ſame, and in different Bodies is proportionable to the Quantity of Matter they contain. And ſince conſequently, if two Bodies containing equal Quantities of Matter, and moving with equal Celerities in contrary Directions, ſo that they impinge directly upon one another, will certainly both reſt or ſtop at the Point of their Concourſe, as alſo ſince it is demonſtrable, that two Bodies moving contrary-wiſe with equal Celerities, and both reſting at their meeting, are equally Heavy; it neceſſarily follows, that two Bodies containing equal Quantities of Matter, are equally Heavy, and therefore were there no Vacuities in Bodies, two Spheres of equal Diameters, ſhould contain equal Quantities of Matter, and conſequently be equally Heavy, *i. e.* two Spheres of equal Diameters, one of Gold, another of Wood, ſhou'd have the ſame ſpecifick Gravities, which being contrary to Experience, there is a Neceſſity of admitting Vacuities in the latter Sphere to anſwer the Difference of their Gravities.

LAW II.

§ XIV. THE Changes made in the Motions of Bodies are always proportional to the impreſs'd moving Force, and are produc'd in the ſame Direction with that of the moving Force.

Effects are alway proportionable to their *adequate* Cauſes, and if any Degree of Force produce any Degree of Motion, a double Degree of the ſame Force will produce a double Degree of Motion, and a triple, a triple, and ſo on; and this Motion muſt proceed in the ſame Direction with that of the moving Force, ſince from this only the Motion ariſes; and becauſe by the former Law, Bodies in Motion cannot change their Direction of themſelves, ſo that unleſs ſome new Force alter its Courſe, it muſt proceed in the ſame Direction with that of the moving Force. And if the Body was before in Motion, the Motion ariſing from this impreſs'd Force, if in the ſame Direction, does ſo much increaſe the former Motion; if it has a contrary Direction, it deſtroys a part of the former Motion, equal to that which is impreſs'd; when it has a Direction oblique to that of the former Motion, it is either added to, or ſubſtracted from the former Motion, according as the Motion ariſing from a Compoſition of theſe two, is determin'd.

Corollary.

§ XV. Hence it is evident, that in the preſent Conſtitution of things, there can be no perpetual Motion. By a perpetual Motion, I mean an uninterrupted Communication of the ſame degree of Motion from one part of Matter to another in a Circle, not as Bodies put in Motion do for ever continue in the ſame, but in ſo far as they are reſiſted or ſtop'd by other Bodies, but a Circulation of the ſame quantity of Motion, ſo that it perpetually return undiminiſh'd upon the *firſt Mover.* For by this Law, the Motion produc'd is but proportionable to the generating Force, and all Motions on this Globe being perform'd in a reſiſting Fluid, *viz.* the Air, a conſiderable quantity of the Motion muſt be ſpent in the Communication, on this *medium*, and conſequently it is impoſſible the ſame Quantity of Motion ſhou'd return undiminiſhed upon the *firſt Mover*, which is neceſſary toward a perpetual Motion. Moreover, the Nature of Material Organs is ſuch, that there is no avoiding a greater or leſſer degree of Friction, though the Machin be form'd according to the exacteſt Principles of *Geometry* and Mechanicks, there being no perfect congruity nor exact ſmoothneſs in Nature; the manner of the Coheſion of Bodies, and the ſmall proportion the ſolid Matter bears to the vacuities in 'em, and the

Nature of the conſtituent Particles of Bodies, not admitting the ſame. Beſides, how very imperfect our moſt finiſhed Mechanick Performances are, a very ordinary *Microſcope* will eaſily diſcover· Now theſe things muſt very conſiderably diminiſh the communicated Force, ſo that it is impoſſible there ſhou'd be a perpetual Motion, unleſs the communicated Force were ſo much greater than the Generating Force, as to recompence the dimunition made therein by all theſe Cauſes, ſo that the impreſs'd Motion may return undiminiſh'd to the firſt *Mover*. But that being contrary to this Law, it is clear that the Motion muſt continually decreaſe, till it at laſt ſtop, and conſequently there can be no perpetual Motion in the preſent State of Things.

LAW III.

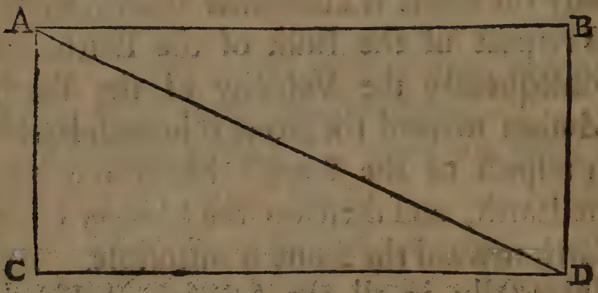
§ XVI. REPULSE or Reaction is always equal to Impulſe or Action, or the Action of two Bodies upon one another is always equal, but with a contrary Direction. *i, e.* The ſame Force with which one Body ſtrikes upon another, is return'd upon the firſt by that other; but theſe Forces are impreſs'd with contrary Directions.

Whatever preſſes or draws another, is as much preſs'd or drawn by that other; if one preſſes a Stone with his Finger, the Stone preſſes his Finger again. If a Horſe draw forward a Stone by a Rope, the Stone does equally draw back the Horſe, for the Rope being equally diſtended, both ways acts upon both equally. If one ſtrike an Anvil with a Hammer, the Anvil ſtrikes the Hammer with equal Force. The Steel draws the Magnet as much as the Magnet does the Steel, as is evident by making both ſwim in water;

ſo in pulling a Barge to Land by a Rope, the Bank pulls the Barge as much as the Barge does the Bank; and in the deſcent of heavy Bodies, the Stone attracts the Earth as much as the Earth does the Stone; *i. e.* the Earth gravitates toward the Stone, as much as the Stone does toward the Earth. And the Motions produc'd by both theſe Gravitations, are equal in both, only the Stone is altogether inconſiderable, in reſpect of the Bulk of the Earth, and conſequently the Velocity of the Earth's Motion toward the Stone is inconſiderable, in reſpect of the Stone's Motion toward the Earth, and therefore the Motion of the Earth toward the Stone is inſenſible. And Univerſally in all the Actions of Bodies, if a Body act on another, and change its Motion any manner of way, that other will make the ſame Change in the Motion of this Body with a contrary Direction, ſo that by theſe Actions there are made equal Changes, not of the Velocities but of the Motion, for the Changes made on the Velocities in contrary Directions, are in a reciprocal proportion to the Bodies.

Corollary 1.

§ XVII. If a Body *A*, be impell'd by two different Forces, one in the Direction *AB*, with the Velocity *M*; another in



the Direction *AC*, with the Velocity *N*, make *AB* to *AC*, as *M* to *N* compleat the Parolelogram *ABCD*, the Diagonal of which is *AD*. The Compoſition of both theſe Forces will make the Body deſcribe the Diagonal *AD*, and in the ſame time as it would have deſcribed either of the the Sides; for becauſe the Force, whoſe

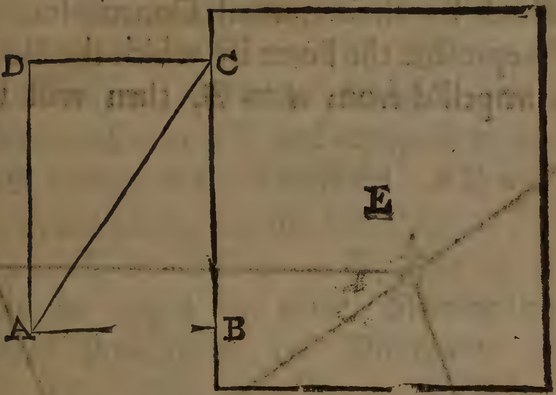
Velocity is *N*, acts in the Direction *A C*, parallel to *B D*, it will not in the leaſt hinder or deſtroy the Velocity in the other Force, by which it tends to the Line *B D*. Wherefore the Body will reach *B D* in the ſame time, whether the Force, whoſe Velocity is *N*, be impreſs'd or not, and therefore in the end of this time it muſt be found ſomewhere in *B D*, in like manner, the Force, whoſe Velocity is as *M*, acts in the Direction *A B*, parallel to *C D*, and therefore will not hinder the Velocity in the other Force in proceeding to *C D*, and the Body will reach *C D* in the ſame time, whether the Force, whoſe Velocity is *M*, act or not, and conſequently, in the end of the ſame time, it muſt be ſomewhere in *C D*, but it cannot be found in *B D* and *C D* both, but at the Point *D* therefore, *&c.*

Corollary 2.

§ XVIII. From theſe Laws, and their neceſſary Conſequences, all the Rules of

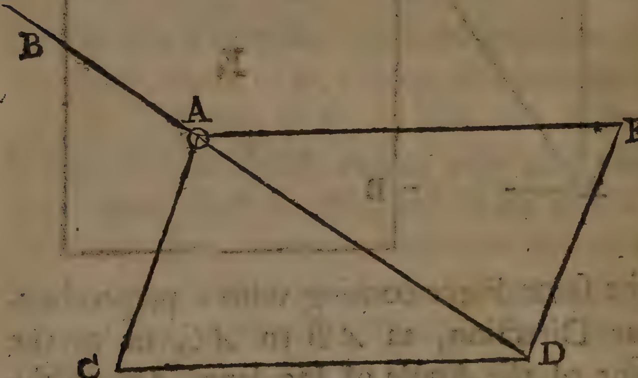
Bodies aſcending or deſcending in vertical Lines, may be deduced, as alſo, the Rules of the Congreſſes and Reflections of two Bodies, as the *Geometers* have ſhewn. From the preceding Corollary, the Method of compounding and reſolving Motions in any given Directions may be drawn, for Example, the Compoſition of the direct Force *A D*, of any oblique ones, ſuch as *A B* and *B D*, as alſo the Reſolution of the direct Force, into any oblique ones, ſuch as *A B* and *B D*, as alſo the *ratio* of an oblique Force to move a Body, to that of the ſame Force coming with a perpendicular Direction to move the ſame Body; for Example, let an oblique Force, as *A C* be impreſs'd upon the Body *E* in *C*, at the Point *C* erect a perpendicular *C D*, and from *A* let fall a perpendicular upon *C D*, and another upon *C B*; then by the former Corollary, the Force *A C* may be reſoved into the two

Forces *AD* and *AB*, of which only *AB* has any Energy to move the Body *E*; wherefore the oblique Force as *AC* is to



the ſame Force coming with a perpendicular Direction, as *AB* to *AC*, or as the ſine of the Angle of Incidence *AB* to the Radius *AC*. The ſame is true of the Energy of an oblique Stroke upon the Body *E*, to that of the ſame ſtriking perpendicularly.

From the ſame preceding Corollary, it follows that if a Body *A* be impell'd or drawn by three different Forces in three different Directions *AB*, *AE*, *AC*, ſo that the Body yields to none of 'em, but continues in *æquilibrio*, theſe three Powers are to one another as three right Lines drawn parallel to their Directions, and terminated by their mutual Concourſes. If *AD* repreſent the Force by which the Body *A* is impell'd from *A* to *B*, then will the



ſame *AD* repreſent the contrary equal Force, whereby it is impell'd from *A* to *D*. But by the former Corollary a Force, as *AD* impelling from *A* to *D* is equipollent to two others, acting in the Directions *AC*, *AE*, to which the other impelling from *A* to *D*, is as *AD* to *AC*, and *AE* or *CD*, reſpectively. So likewiſe two Forces acting in the Directions *A C*, *A E*, and being equipollent to the Force Acting in the Directions *A D*, from *A* to *D* will be to the Force acting according to the Direction *A D*, from *A* to *D*, as *A C*, *A E* to *A D*; and therefore the Forces acting in the Directions *A C* and *A E*, and equipollent to the Force acting in the Direction, *A D* are to this Force acting in the Direction *A D*, as *A C*, *A E*, or *C D* to *A D*, that is, if a Body be urg'd by three different equipollent Powers in the Directions *A B*, *A C*, *A E*, theſe three Forces ſhall be to one another as *A D*, *A C*, *C D* reſpectively, *q. e. d.* and this ſingle Propoſition is the Foundation of all the Mechanicks, as ſeveral *Geometers* have expreſly ſhown; ſo that it is plain, theſe three Laws do virtually comprehend all the Rules of Mechaniſm, and conſequently, if any appearance contradict theſe Laws, or their neceſſary Conſequences, it is not to be Mechanically accounted for. So then in our future Inquiries, we have nothing to do to ſhow any thing is Immechanical, or not according to the eſtabliſh'd Laws of Nature; but clearly to evince, that it contradicts ſome of theſe Laws or their Corollaries.

Corollary 3.

§ XIX. Hence it follows that a Body can't move conſtantly in an *Orbit*, with the ſame Degree of Motion from one ſingle impreſs'd Force. If it move in an *Orbit*, let a *Polygon* be inſcrib'd in it, then ſince the Angles of this *Polygon* are Oblique, the Degree of the Motion of the Body moving in this *Polygon*, muſt decreaſe at every *Angle* in proportion to the Sine of the *Angle* of Incidence, (ſuppoſing the *Radius* always the ſame) by the former *Corollary*; but every *Orbit* is equivalent to a *Polygon* of an infinite Number of *Angles*, and conſequently the Degree of Motion and Velocity ariſing from one ſingle Impulſe, muſt continually decreaſe by a Body's moving in an *Orbit*, and ſo muſt at laſt be quite ſpent, and the Body will be at reſt.

Corollary

Corollary 4.

§ XX. Hence there can be no perpetual Motion ariſing from one ſingle Impulſe, for this Motion muſt be propagated in an *Orbit*, that it may return upon the firſt *Mover*, and if ſo, it muſt continually decreaſe, and at laſt ſtop.

Corollary 5.

XXI. Hence it is evident, that the *Planets* and their *Satellits*, the *Comets* and the other Celeſtial Bodies do not move in their *Orbits* (tho' we ſhou'd ſuppoſe 'em ſolid) by the Force of one ſingle Impulſe, but are kept kept in by ſome other Powers. We ſee theſe Bodies do continue their Motions without any ſenſible Alterations, which they cou'd never do if they mov'd only by the Force of one ſingle Impulſe. Let us then Enquire how it comes about, that theſe Bodies do perſevere in their Motions, and do conſtantly move round in the ſame Tracts, without making the leaſt Deviation; now, that can happen but one of theſe two ways, *viz.* Either by the Force of ſome *Celeſtial* Fluid (call'd a *Vortex*) which carries 'em about, or by ſome *Retentive Central Force* which hinders 'em from runing out in ſtrait Lines, when they are once put in Motion by the Fingers of him who fram'd this marvellous *Machin* of a World.

§ XXII. In order to account for the *Celeſtial* Appearances, *Des Cartes* ſuppoſes the Matter of this Univerſe to have been at firſt divided by Almighty God, into innumerable little equal Parts, each endow'd with an equal Degree of Motion, both about its own proper *Center*, and ſeperatly among themſelves, ſo as to conſtitute a Fluid; as alſo that ſeveral Collections of theſe Parts, were endow'd with a Motion about different Points (at equal Diſtances) as common *Centers*, ſo as to compoſe different *Vortices*, and that theſe Parts being made round by ſuch inteſtine Motions, did produce *Globules* of different Magnitudes, which he calls the Matter of his *ſecond Element*; as alſo that the ſmall Raſpings and Fileings of the Angular Points of theſe *Globules* driven violently many different ways, did make up the Matter of his *firſt Element*; and ſeeing there wou'd be more of this *firſt Element* than was ſufficient to fill the Vacuities between the *Globules* of the *ſecond Element*, he ſuppoſes that the remaining part wou'd be driven toward the *Center* by the Circular Motion of theſe *Globules*, which did for that reaſon recede from it; and being there amaſs'd in a Sphere, wou'd in the *Center* of every *Vortex* produce a Body like the *Sun*; that the Sun being thus fram'd, and moving about its own *Axe* with the Motion of the reſt of the Matter of the *Vortex*, wou'd neceſſarily throw out ſome Parts of its Matter through the Vacuities of the *Globules* of the *ſecond Element*, which conſtitute the *Vortex*, eſpecially at theſe Places which are diſtant from its *Poles*, receiving by theſe *Poles* as much as it loſes about the *Eccliptick*, and by this wou'd be able to carry round with it theſe *Globules* which are neareſt, with the greateſt Velocity, and the remoter with a leſs; and that ſo of neceſſity theſe *Globules* that are neareſt the *Center* of the *Sun* would be leaſt, for were they greater or equal, they wou'd by reaſon of their Velocity, have a greater centifrugal Force, and therefore recede from the *Center*. Now ſhou'd it happen that any of theſe *Sun-like* Bodies in the *Centers* of the ſeveral *Vortices* ſhou'd be ſo incruſtated and weaken'd, as to be carried about in the *Vortex* of the true *Sun*, if it were of leſs Solidity, or leſs capable of Motion than the *Globules*, towards the extremity of the *Solar Vortex*, then it wou'd deſcend toward the *Sun*, till it met with *Globules* of the ſame Solidity, and capable of the ſame Degree of Motion with it, and being fixt there, it wou'd for ever be carried about by the Motion of the *Vortex*, without either approaching to, or receding from the *Sun*, and ſo become a *Planet*. Suppoſing this true then, we may imagine our *Syſtem* to have been at firſt divided into ſeveral *Vortices* in the *Center*, of which was a lucid, ſpherical Body, and that ſome of theſe being gradually incruſtated, were ſwallow'd up by others, more powerful and bigger, till at laſt they were all deſtroyed and carried away by the biggeſt *Solar Vortex*, except ſome few that were thrown of in right Lines from one *Vortex* to another, and became *Comets*. Hence it appears that the *Planets* that are neareſt the *Sun*, are leaſt ſolid, which is *Des Cartes*'s Reaſon, why the *Moon* ſhows always the ſame Face to us, becauſe that *Hemiſphere* that is oppoſite to the *Sun* and *Earth*, is ſomewhat more ſolid than the other. As alſo that the Matter of the *firſt Element*, which makes up the Body of the *Sun*, moves with greater Velocity the Parts of the *Vortex*, and the Bodies ſwiming therein, that are neareſt it, than thoſe that are remoter, which is the reaſon why the *Planets* next the *Sun*, finiſh their Periods ſooner than thoſe that are more remote; and that theſe *Planets* move about their own *Axes*, becauſe they were *Sun like*, lucid, and revolving Bodies before.

§ XXIII. Now not to mention the many Defects in the Mechanical Production of this immaginary *Syſtem*, I ſhall only take Notice (as Dr. *Gregory* has) of the known *Celeſtial* Appearances it contradicts; and the Abſurdities wou'd follow, tho' we ſhou'd allow the Author all that he wou'd have granted. And, 1. It is certain that a *Vortex* produc'd by the Revolution of a *Sphere*, about a giv'n *Axis*, wou'd be propagated *in infinitum*, if nothing did hinder it; and ſeeing there muſt be as many ſuch *Vortices* as there are fixt Stars, one *Vortex* wou'd neceſſarily run into another, and every Particle wou'd be acted by a Motion compounded, of the Motions of all the *Central Spheres*, which is abſurd and contrary to that Conſtancy and Limitation obſervable in the Celeſtial Appearances. 2. Since the Motion of the Parts of the *Vortices* neareſt the *Center* is ſwifter than that of the more remote, they will preſs upon the exterior Parts, and thereby perpetually communicate ſome part of their Motion to them, and therefore

fore theſe interior parts of the *Vortex,* will be continually loſing ſome part of their Motion, which never being reſtored, theſe parts muſt gradually move ſlower, till at laſt the Motion is quite deſtroy'd. 3. According to this *Hypotheſis*, each *Planet* is of the ſame Denſity with the parts of the *Vortex* in which it ſwims, and is govern'd by the ſame Laws of Motion, and is as it were, only concreted parts of the *Vortex*: Now the times of the periodical Motion, of Bodies, carry'd about by a *Vortex* are in duplicat proportion of the Diſtances from the Center; whereas the Squares of Times of the periodical Motions of the *Planets*, are as the Cubes of the Diſtances from the *Center*, and conſequently the *Planets* cannot be carry'd about by a *Vortex*. 4. If a *Vortex* run out *in infinitum*, then a Body carry'd round by it, wou'd certainly deſcribe a perfect Circle, unleſs ſomething ſolid did hinder it, and therefore, the greater Diſtance there were between theſe ſolid Bounds, or the larger the Baſon be which contains the *Vortex*, in reſpect of th *Orbit* of the Body carry'd about in it, the nearer wou'd this Orbit approach to a Circle. *i. e.* The Excentricity of the *Planets* neareſt the *Sun*, would be leſs than that of thoſe more remote, the contrary of which is true, for that of *Mercury* is greater than that of *Saturn*. Moreover, ſince the *Planets* in this *Vortex* wou'd neceſſarily move in Orbits nearly ſimilar to that of the ſides of the containing Baſon, it wou'd follow that the *Aphelia* of all the *Planets* ſeen from the Sun, wou'd be directed towards the ſame fixt Stars: but this too is contrary to Obſervation. Likewiſe the Matter of the *Vortex* (as of every Fluid) when bound up within ſtrait Bounds, muſt neceſſarily move faſter than when enlarg'd in a wider Channel; *i. e.* the *Planets* muſt move faſter in their *Perihelia*, than in their *Aphelia*, which contradicts Experience. 5. A Body carry'd about in a *Vortex* of the ſame denſity with it, wou'd neceſſarily deſcribe a Circle to whoſe Plane, the Axis of the central Body which produces the Circulation of the Fluid, wou'd be perpendicular; but there is not one *Planet* to the Plane of whoſe Orbit the *Sun*'s Axis is perpendicular. Laſtly, The *Comets* have their Orbits, not only oblique, but ſometimes at right Angles with the Plane of the Ecliptick, ſometimes the Courſe of theſe *Comets* is Diametrically oppoſite to that of the *Sun*; they perſevere in their Motions without any change, they deſcribe equal *Area's* by a *Radius* from the *Sun* in equal times, they enter into the *Vortex* of the *Sun*, all which is impoſſible, if the *Solar Vortex* mov'd round with Force ſufficient to carry theſe vaſt Bodies of the *Planets* along with it.

§ XXIV. This *Hypotheſis* is ſomewhat altered and mended by the famous Mr. *Leibnitz*, he accomodates it better to the Celeſtial Appearances, and makes it agree more exactly to the Rules of *Geometry*. He firſt of all ſhows, that all Bodies which in a Fluid deſcribe a *Curve-Line*, are mov'd by the Fluid, for of themſelves they wou'd deſcribe right Lines, and nothing but the Fluid concurs to turn them out of their way. He next ſhows, that every *Planet* is carry'd about by a Motion compounded of two other Motions, *viz.* the *Harmonical Circulation* of the carrying Fluid, and the *Paracentrical Motion* of acceſs to, or receſs from the *Sun.* The *Planets* deſcribe *Area's* by a *Radius* from the *Sun*, proportional to their times. Now the Fluid that carries the *Planets* muſt of neceſſity circulate ſo as to produce this effect, which cannot be done otherwiſe, than by ſuppoſing innumerable concentrical Orbs of exceeding thinneſs to make up the *Vortex*, every one of which has its own proper way of Circulation, *viz.* thoſe Orbs that are neareſt the *Sun* circulate faſteſt, and the Velocities of the Circulations are every where reciprocally proportional to the Diſtances of the reſpective Orbs from the *Sun*, which will neceſſarily make the *Planet* in whatever part of *Vortex* it is, deſcribe equal *Area's* in equal Times; for theſe *Area's* are in a compounded proportion of their *Radii* or Diſtances from the *Sun*, and a reciprocal proportion of the Arches or Lengths of the Circulations, which in this caſe will make a proportion of equality, and this Law of Circulation of the *Vortex* he calls *Harmonical.* The *Paracentrical* Motion is compounded of two others, *viz.* the *Excuſſory* Impreſſion of the *Harmonical* Circulation, whereby all Bodies moving in a *Curve*, endeavour to recede from the *Center* by the *Tangent*, and the Attraction of the *Sun* or the Gravitation of the *Planet* toward it; and this *Leibnitz* is of Opinion, ariſes from an Impulſe communicated by the Circulating Fluid. Now ſince the *Planets* move in *Elliptick* Orbits, in one of whoſe *foci* the *Sun* is, and by a *Radius* from the *Sun* deſcribe equal *Area's* in equal Times, which no other Law of a Circulating Fluid, but the *Harmonical* Circulation can Account for, we muſt find out a Law for the *Paracentrical* Motion, that may make the Orbits *Elliptick.* The *Excuſſory* Impreſſion of the Circulating Fluid, wou'd throw off the *Planet* from the Center by the *Tangent.* Wherefore the Attraction of the *Sun*, or the Gravitation of the *Planets* towards it, muſt be ſufficient to deſtroy this Effect; and beſides, to make them move in *Elliptick* Orbits, which cannot be brought about, unleſs this Attraction or Gravitation be reciprocally as the Squares of the Diſtances from the *Focus*, which is the Sum of *Leibnitz*'s Doctrine upon this Head.

§ XXV. But even this Account of the Celeſtial Motions is undoubtedly falſe and inſufficient for theſe Reaſons. 1. The *Comets*, as was formerly ſaid, have their Orbits, ſome of them very oblique, nay, ſometimes at right Angles with the *Zodiak*, and ſometimes the Courſes of theſe *Comets* are quite contrary to that of the *Planets*: Now the *Comets* deſcribing about the *Sun Area's*, proportional to the times, moſt be carry'd about by a *Harmonically* circulating Fluid, as well as the *Planets*, and thus we ſhou'd have *Vortices* contrary to *Vortices*, which is very abſurd. 2. This Suppoſition is not only unreaſonable, but diſagreeable to the uniform Simplicity of Nature; nor is there any thing in the Motions

tions of the Heavenly Bodies ſo difficult to explain, as this very *Hypotheſis*, which is introduc'd to account for them. Beſides, 3. In equable Motion, the Times are always as the Spaces directly, and the Velocities reciprocally; but in a Circular Motion, the Spaces in one Revolution are as the *Radii*, and in an *Harmonical* Circulation, the Velocities are as the *Radii* reciprocally, and therefore the periodical Times of a Fluid circulating *Harmonically*, are in the Duplicate Proportion of the *Radii*. Now the periodical Times of the *Planets* are in Seſquiplicate Proportion, and not a Duplicate Proportion of the Diſtances from the *Center* or the *Radii*, and conſequently the *Planets* cannot be carried about by an *Harmonically* circulating Fluid. To this it may be anſwer'd, that this *Harmonical* Circulation is not continued from *Mercury* to *Saturn*, but is interrupted, and reaches only from *Mercury*'s *Perihelium* to his *Aphelium*, and there breaks off, and begins again at *Venus*'s *Perihelium*, and reaches to her *Aphelium*, and is there again interrupted,

rupted, and ſo on through the whole Syſtem of the *Planets* : But what a ghaſtly and unſightly kind of Deformity there wou'd happen on this Suppoſition, every one may eaſily ſee, this is not like the unform and ſimple Meaſures of Nature. Beſides, the *Comets* moving forward in the *Zodiack*, paſs through all theſe Chaſms and Interſtices, and notwithſtanding, move in the ſame manner, as if they were carried by a Fluid, circulating *Harmonically* according to ſome uniform Law, neither do their Appearances ſhew the leaſt Suſpicion of theſe Interruptions.

§ XXVI. It being thus prov'd, that the Celeſtial Bodies do not revolve by the means of any circulating Fluid, they muſt be kept in their Orbits, by ſome *Attractive* Power in the *Sun*, or by ſome gravitating Power in them towards him, which is the ſame thing, ſince it muſt be mutual by the third Law. This Gravitating or Attracting Power of the great Bodies of the Univerſe towards one another, ſome *Philoſophers* endeavour *Mechanically* to account for, from the Action of a Subtile Matter, which violently whirling round the *Sun* in general, the *Earth* and the reſt of the *Planets* in particular, and acquiring thereby a Power of receding from the Center, impels Bodies towards that Center about which the ſtrongeſt Circulation is made; or being driven with an immenſe Velocity in right Lines according to all poſſible Directions, impels the Body according to the Direction of that part of this Subtile Fluid, which is leaſt reſiſted by the interpoſition of other Bodies. And thus, not only Bodies within the Sphere of the *Earth*'s Activity are impell'd towards it, but alſo the *Planets* do gravitate towards the *Sun*, but without entering into the particular manner of the Explication of Gravitation according to this Scheme, there be two or three Objections againſt all the poſſible Accounts of Gravity in particular, or Gravitation in general from the Circulation of a Subtile Matter. 1. It is impoſſible from the firſt Part of this *Hypotheſis*, to account for Bodies gravitating towards a Point, for the

the Motion *quaquà verſum* in a great Circle of the Sphere, which is alledged to ſalve this Difficulty, is a Contradiction to Nature, no ſuch thing being either conceiveable or poſſible. 2. It is impoſſible to explain whence the Circular Motion of this ſubtile Fluid comes, there muſt be conceiv'd another ſubtile Fluid Moving after ſome certain manner to produce the Motion of of that Fluid, which is the Cauſe of Gravity, and ſo on in *infinitum*, or elſe we muſt admit its Motion without any Cauſe, which is harder to conceive than Gravity it ſelf. 3. That Matter which is the Cauſe of Gravity, or by whoſe Motion it is produc'd in all the poſſible *Mechanical* Explications thereof, muſt be without Gravity which is Abſurd Matter being every where in reaſon to be ſuppos'd of the ſame uniform Nature, and its Gravity to be always proportional to the Quantity of its ſolid Maſs. 4. Bodies from the Impulſe of a Fluid can only gravitate in proportion to their Surfaces, and not according to their Quantity of Matter, which is contraray to Experience; for we find all Bodies gravitate in proportion to their Solidities, *i. e.* their Quantity of Matter; And tho' this Difficulty may be remov'd, by ſuppoſing Bodies to conſiſt originally of *Cylinders* of infinitely ſmall *Baſes*, for on ſuch a Suppoſition, theſe *Cylinders* wou'd be to one another as their Surfaces, their *Baſes* being nothing, and conſequently, the Gravities of Bodies, which by the Action of this ſubtile Fluid are as their Surfaces, wou'd be alſo as their Solidities, *i. e.* the Quantities of Matter they contain, ſince the Surfaces of the original Particles of Bodies are as their ſolid Contents. Yet this is ſo very hard a *Poſtulate*, to require Bodies to be diverſified, only by the Lengths of their primitive conſtituent *Cylinders*, that I can't ſee how it can poſſibly account for all the varieties of Colours, Taſtes and Smells, and other ſenſible Qualities of Bodies, which ariſe from the Diverſities of the Texture and Figure of their conſtituent Parts. But that which in my Opinion, overthrows all ſuch *Mechanical*

Accounts, however artfully contriv'd, is that. 5. There ſeems to be neceſſary toward a full Explication of the Appearances of Nature, ſeveral different Conditions of this Univerſal Law of *Gravitation*, which cannot be *Mechanically* explain'd, without ſuppoſing different Syſtems of this Fluid, to move after different Manners, and according to different Laws, which will neither accord eaſily together, nor ſeem like the Limitations and Simplicity of Nature. That there are different Conditions of the Univerſal Law of *Gravitation*, neceſſarily to be ſuppos'd, ſeems evident from the Nature of Light, as Mr. *Newton* has explain'd it from certain Experiment; and there are other Appearances in Nature, that ſeem to require Conditions different from that which governs the the Motions of the Celeſtial Bodies, and Cauſes the inflexions of Light, as ſhall be afterwards ſhown. Now, to account *Mechanically* for theſe different Conditions of the General Law of *Gravitation*, there muſt of neceſſity be ſuppos'd various and different Syſtems of this ſubtile Fluid, which looks a little odd, eſpecially if we conſider, that is not as yet known how many and how different theſe Syſtems muſt be ſuppos'd to account for all the various Conditions of this General Law, that may hereafter be diſcovered neceſſary to explain the various Appearances of Nature. 6. Laſtly, this whole Affair is more Naturally and Simply to be accounted for from Principles now to be laid down.

Corollary

§ XXVII. From what has been ſaid it appears, that the Attraction or Gravitation of Bodies toward one another, is not to be *Mechanically* accounted for, and ſince it has been likewiſe ſhown, that the *Planets* cannot continue their Motions in their Orbits, without the Suppoſition of ſuch an Attraction or Gravitation, it is evident, that this muſt be a Principle annex'd to Matter by the *Creator* of the World; it is a Principle no ways eſſential to Matter, ſince it is the Source and the Origin of the Celeſtial Motions, as Mr. *Newton*, and after him Dr. *Gregory* has demonſtrated. And by the firſt Law of Nature and its Corollaries, no kind of Motion is eſſential to Matter, and therefore Attraction or Gravitation cannot be eſſential to it; it is not a Reſult from the Nature of Matter, becauſe the efficacy of Matter is communicated by immediate Contact, and it can by no means act at a diſtance; for we ſee an Object, becauſe the Light reflected from thence ſtrikes immediately upon our Organs of Viſion, we ſmell, becauſe parts of the odorous Body touch the Nerves of our *Noſtrils*, and univerſally all the other Natural Effects of Material things are perform'd by the meer Impulſe of one Body on another, whereas this Power of Gravitation acts at all Diſtances without any *Medium* or Inſtrument to convey it, and paſſes as far as the Limits (if any ſuch there are) of the Univerſe. Beſides, by the firſt Law of Nature, Matter is entirely paſſive in its Nature, and can no more tend to, or draw other Bodies then it can move of it ſelf; likewiſe ſuppoſing this Gravitation of the parts of Matter toward one another deſtroy'd, yet ſtill Matter wou'd be the ſame extended ſolid Subſtance. Moreover, if there were but one indiviſible Part of Matter in being, it could not be ſaid to have this Property, it being a Relative one, and having reſpect only to other Parts which it attracts; whereas impenetrability or any other of the eſſential Properties of Matter continues with it, ev'n when it becomes indiviſible. Laſtly; That cannot be eſſential to Matter which is intended or remitted, but this Property increaſes and diminiſhes reciprocally as the Squares of the Diſtances diminiſh or increaſe, whereas impenetrability, and the other eſſential Attibutes of Matter are always the ſame. On all which Accounts, it's plain that this Univerſal Force of *Gravitation* is the effect of the *Divine Power* and *Virtue*, by which the Operations of Material Agents are preſerv'd. And this Power of *Gravitation* being thus impreſs'd on Matter, is one reaſon of the Diſtinction between the Laws of *Creation* and *Nature*, for tho' the *Energy* of the Impreſſion does ſtill laſt, yet its not being eſſential to Matter, nor ariſing from its Nature, is the reaſon why it ought not to be reckon'd among thoſe Laws which ariſe from the particular Texture, Figure and Diſpoſition of Bodies, ſuch as moſt of the Laws of Nature or Motion are. The Chief Difficulties that I can find have ſtraitned Learned Men, in admitting this Principle of the Univerſal Law of the *Gravitation* of Bodies upon one another are, 1. That they cannot conceive how this Principle can be *Mechanically* accounted for, and they think it *Unphiloſophical* to admit any Principle in the Explication of the Appearances of Nature which can't be thus acacounted for. It is indeed in my Opinion certain, that this Priciple cannot be *Mechanically* accounted for; for there is no other *Mechanical* Cauſe conceivable, this Principle of the *Gravitation* of Bodies upon one another, can ariſe from, but the Motion of ſome ſubtile Fluid, and were there no other Argument againſt all poſſible Explications of *Gravitation* ariſing from the Motion of a ſubtile Fluid, but this one, *viz.* that thereby theſe Parts of Matter which are the Cauſe of, or produce *Gravitation*, are upon this Suppoſition, deſtitute of Gravity; I ſhou'd think it ſufficient to prejudice any inquiſitive Man againſt ſuch Explications; for it's certain that Nature is uniform and conſiſtent with it ſelf, and wou'd not deprive one part of Matter of ſo Cardinal a Property, with which ſhe had endow'd all the reſt. But ev'n the admiſſion of ſuch an *Hypotheſis* removes us but one Step further from *Immechanical* Principles, for the Cauſe of the Motion of this ſubtile Fluid, which is the Cauſe of Gravity, is it ſelf *Immechanical.* Nor has any Body ever pretended to aſſign any other Cauſe of the Motion of this ſubtile Fluid, but the *Omnipotent Cauſe* of the *Univerſe*; and ſince we muſt of Neceſſity admit the Motion of this ſubtile Fluid, which is the Cauſe of *Gravitation* to be unaccountable without a *Firſt Cauſe*, why may we not rather admit this *Firſt Cauſe* to have impreſs'd this Property in Matter, ſince that this Difficulty is the ſame in both; and that beſides, the firſt Suppoſition is burthen'd with ſeveral Additional ones, to which the ſecond is not liable. There has never been any Syſtem of *Natural Philoſophy* offered to the World as yet, that does not require ſome *Poſtulates* that are not to be accounted for *Mechanically*; the feweſt any one pretends to, are the Exiſtence of Matter, the Impreſſion of Rectilinear Motions, and the preſervation of the Faculties of Natural Agents, which no Man has pretended to account for from Principles of *Mechaniſm*; and the Impreſſion of an *attractive Faculty* upon Matter, is no harder *Poſtulate* than any of theſe; but ſince it is Matter of Fact and Demonſtration, that Matter is in poſſeſſion of this Quality; for we daily ſee, that the Earth draws to its Center all Bodies within its Activity, we muſt allow of it, whether it be to be *Mechanically* accounted for or not; and ſince it is not to be accounted for from *Mechanical* Principles, as I think, I have demonſtrated, we muſt of neceſſity refer it to the Power and Influence of the *Firſt Cauſe* of all things. 2. Another Difficulty ingenious Men have in the Conception of this Quality in Matter, is how it can act at a Diſtance without any *Medium* to convey this Action, as of neceſſity it muſt. Now, were there no other Difficulty of the like Nature in Philoſophy but this one, it might ſtumble judicious Perſons; but we know the manner of *Thinking* and *Reflection*, of *Remembring* and *Senſation*, are things not eaſily to be explain'd, and yet we muſt admit them. The Communication of Motion from one part of Matter to another, the Continuation of a Body in Motion after it is removed from the impellent Body, and ev'n the firſt Production of Matter and Motion, are not to be accounted for, and yet there is no denying that ſuch things really are, when we are capable to explain how our Souls and our Bodies act mutually upon one another, we may come to be able to conceive how Matter acts at a Diſtance without any *Medium*; but till then, it is ſufficient to know, that ſuch a Quality is actually lodg'd in Matter, and that it is the Cauſe of all the Great and Uniform Appearances of Nature. No wiſe and honeſt Man, who throughly underſtands the Matter, will offer to explain by Rules of *Mechaniſm*, how this *Syſtem* of things was produc'd, nor how the Faculties of Material Organs are preſerv'd, whence they aroſe, and what way they communicate their Actions and Influences to one another; it will ſuffice ſuch, from the Preſent Appearances to inveſtigate the Powers and Forces of Nature, and from theſe to account for future Obſervations and Appearances; if we admit an *infinitely Wiſe and Powerful Being* to have made this, World, there will be little Difficulty in allowing him to have impreſs'd on Matter what property he pleas'd, and if we will not admit of ſuch a Being, there are much greater and harder Difficulties in the *Mechanical* Explication of the Nature of things to be ſurmounted, as ſhall be afterwards ſhown.

§ XXVIII. The great and primary *Law* then, imprinted by the Author of Nature upon all the Bodies of this Univerſe, is that every part of every Body attracts or gravitates toward every part of every other Body, and the moſt general Conditions of this Law are, that the *Force* by which one part attracts another in different Diſtances from it, is reciprocally as the Squares of thoſe Diſtances, and that at the ſame Diſtance, the *Force* of the Attraction or Gravitation of one part toward divers others, is as the Quantity of Matter they contain: By the Virtue and Efficacy of this Law, the *Planets* muſt perpetually move in *Elliptick* Orbits, if they meet with no reſiſtance in the Spaces in which they move, (their Diſtances from the *Sun*, and their Rectilinear Motions being once adjuſted by the Author of Nature,) and in ſuch a manner, that a Line drawn from the *Sun* to them, deſcribes equal *Area's* in equal Times; and their *periodical* Revolutions will be in a *ſeſquiplicate* proportion of their middle Diſtances. By Virtue of the ſame Law, and of theſe Conditions, the *Moon* will for ever turn round the Earth, as the Earth doth round the *Sun*, and the *Sattellits* of *Saturn* and *Jupiter* round them; As alſo the *Comets* will in very oblong *Elliptick* Orbits deſcribe about the *Sun* equal *Area's* in equal times; But becauſe the *Sun*, not only attracts the *Planets* and *Comets*, as alſo theſe the *Sun*, but likewiſe the *Planets* attract one another, their Orbits will be ſomewhat irregular, and differ from exact *Ellipſes* which will be more ſenſible in the Motions of the *Moon*, becauſe She is ſo near to us; and this one Conſideration, well apply'd, will account for all the Irregularities hitherto obſerv'd in the Celeſtial Appearances, as Mr. *Newton* and after him Dr. *Gregory* has ſhown; Likewiſe ſince a great part of this our Globe is covered over with Water, it is plain that by the Force of this Attraction of the *Sun* and *Moon*, the Water that lyes directly under them will be rais'd above its ordinary Level, which will likewiſe happen if they are directly in the oppoſite part of our Globe, becauſe the remoter parts of the Water will be leſs attracted than the nearer, and the Motions produc'd in the Waters by the attraction of theſe two *Luminaries* can't be obſerv'd ſeperately, but their Forces make up a compound Motion, which at new and full *Moon* is greateſt, and leaſt at the *Quadratures*, and theſe effects are variouſly limited by the different Diſtances of theſe *Luminaries* from the Earth, their *Declinations* from the *Æquator*, and the various *Latitudes* of Places. By this Gravitation, Bodies on this Globe will preſs towards its Center, tho' not exactly thither neither, by reaſon of the *oblate ſpherodical* Figure of the Earth ariſing from its diurnal Rotation about its Axis. Thus we ſee this one Principle will account for all the great and conſtant Appearances of Nature, and none but this will exactly anſwer any one, much leſs them all, which is a demonſtration of its Truth. And were not our Terreſtrial *Phyſiology* more complicated than the Celeſtial (by reaſon of the multiplicity of different Attractions proceeding from the many different Bodies that ſurround any particular one) we ſhould doubtleſs ſee the Extent of this Principle, in accounting for the more minute, and leſs conſtant appearances on this our Globe, as in a great many we actually are. Add to theſe Conſiderations, that we are certain by the Effects, that the Gravitation by which the *Planets* are kept in their Orbits, and by which the *Moon* turns round the Earth, is of the ſame Nature with that by which heavy Bodies tend toward the Center of the Earth, and conſequently, ſince we feel that Terreſtrial Bodies are attracted by the Earth, and ſince we know by the *ſecond Law* of Nature, that Action and Reaction are mutual and equal, it is plain that every part of Matter attracts every other part, and that the Force of this *Attraction* (as all other Virtues propogated round in a Sphere) is reciprocally as the Squares of the Diſtances from the Center of the Action. In ſhort, ſince Action and Reaction is mutual, and ſince the *Primary Planets* gravitate towards the *Sun*, as alſo the *Secondary Planets* tend toward the Primary ones as the Center of their Motions, and ſince the Decreaſe and Increaſe of this Gravitation is of the ſame Nature with that of our Terreſtial Gravity, ſince likewiſe the *Sun* diſturbs the Motion of that *Moon*, and the *Sun* and *Moon* thoſe of our *Earth*, it is plain they all, *Sun*, *Moon*, *Planets* and their *Satellits*, mutually gravitate upon one another.

§ XXIX. Having thus in the General, eſtabliſh'd the Laws *Laws of Nature*, and deduc'd ſuch Conſequences from 'em as we found neceſſary to clear ſome Parts of the following Diſcourſes; having likewiſe ſhown the Neceſſity of admitting the Univerſal Law of *Gravitation* to ſolve the Celeſtial Apperances, and hinted the great Uſe of this Principle in the Celeſtial *Phyſiology*, let us next proceed to ſome of the moſt *Univerſal* of our Terreſtial *Phænomena*; and firſt of all, let us enquire into the Nature and Cauſe of Fluidity, which ſeems to conſiſt principally in the *Mobility* of ſome parts, without carrying along with 'em the reſt, or the eaſie ſlipping of ſome Parts upon others unmov'd mov'd, at leaſt, not mov'd after the manner of ſolid Bodies. All the Bodies in the Univerſe are Originally compounded of ſolid Parts, tho' not indiviſible, yet very ſmall and firm, and Fluids muſt neceſſarily take in theſe four Conditions. 1. That their Parts be extremely little, *i. e.* ſo very ſmall, that no Eye, however aſſiſted, be able to perceive their Magnitude, we have been able to diſcover the Figures of Bodies ſwiming in Fluids, but no one as yet has been able to diſtinguiſh the *Figures* or *Magnitudes* of the conſtituent Parts of *Liquors.* 2. That their Figures be *ſpherical*, or at leaſt *ſpheriodical* or approaching to one of theſe, ſo that they may touch only in a Point, and by conſequence, one Particle may eaſily ſlip upon another, and for this End. 3. They muſt be exactly ſmooth and poliſh'd, and ſubjected to the Univerſal Law of Gravitation, whereby each Particle of the Fluid attracts another, whence that coheſion in the Parts of the fineſt natural Fluids proceeds; but their Gravity muſt be ſuch, that the Force thereof may eaſily exceed the Force of their Coheſion; and here we are to diſtinguiſh between theſe Fluids, generated by the Force of the Fire, and thoſe that are naturally ſuch, there being no neceſſity of attributing any particular Figure to the Parts of the firſt Kind, which own their Fluidity to the Force of the Particles of Fire, which tear aſunder the Parts of ſolid Bodies, and keep 'em in a perpetual Agitation, and thereby make 'em appear in the Form of a Fluid, whereas the Appearances of natural Fluids do neceſſarily require the Conditions in their Parts juſt now aſſign'd. 4. The Particles of natural Fluids muſt be ſimilar, of equal *Diameters*, of equal Solidity, and conſequently of equal ſpecifick Gravities, that they may be *Homogeneous*, and of the ſame uniform Nature; from theſe general Suppoſitions, all the general Appearances may be eaſily accounted for.

§ XXX. Water ſeems to conſiſt of ſmall, ſmooth, hard, porous, ſpherical Particles of equal *Diameters*, and equal ſpecifick Gravities, which have between 'em ſome Spaces ſo large, and ranged in ſuch a manner, as to be pervious on all Sides. Their Smoothneſs, makes 'em ſlip eaſily upon one another, their *Sphericity* keeps 'em from touching one another in more Points than one, by both which, their Frictions in ſliding upon one another is rendered the leaſt poſſible; their Hardneſs is the reaſon why Water is incompreſſible, when the Air lodg'd in it, is exhauſted.

§ XXXI. The *Poroſity* of the Particles of Water (which is ſo great, that a *Cubical* meaſure of Water contains at leaſt forty times more Pores than Parts, for Water is nineteen times lighter than Gold, and conſequently nineteen times rarer than Gold; and Gold will by much preſſure, let Water paſs through it, and ſo may be ſuppoſed to have more Pores than ſolid Parts, and by conſequence, Water has above forty times more Pores than ſolid Parts) accounts not only for the different *Specifick* Gravity between Water and other Fluids, ſuch as *Mercury*, but alſo why it is more eaſily concreted into a ſolid Form than other Fluids are. *Cold* and *Freezing*, ſeem to proceed from ſome *Salin* Subſtance floating in the Air; we ſee that all Salts, but more eminently ſome, mix'd with Ice, prodigiouſly encreaſe the Effects and Force of Cold, we ſee all *Salin* Bodies produce a Rigidity and Stiffneſs in the Parts of Bodies to which they are apply'd, much like the Effects of Freezing, we know, from Mr. *Boyle*'s *Hiſtory of Cold*, that Freezing increaſes the Dimenſions both of Solid and Fluid Bodies, *Microſcopial Obſervations* inform us, that the Figures of ſome Salts, before they ſhoot into Maſſes, are thin double wedg'd-like Particles, which have abundance of Surfaces in reſpect of their Solidity, which is the reaſon why they ſwim in Water when they are rais'd once, tho' they be ſpecifically heavier. But this Effect may be more juſtly attributed to the ſame Cauſe that is preſently to be ſhown to be the Cauſe of Freezing, *viz* the ſmall Points of the Salts getting into the Pores of the Particles of Water, whereby theſe Salts are ſuſpended in the

Water. In Summer the Heat of the Sun diſſolves the *ſalin* Particles into a Fluid, breaks off their ſlender Points, and by its Action, keeps 'em in a perpetual Motion, ſo that they cannot ſhoot into a ſolid Wedge, and conſequently are not able to produce the *Appearances* of *Cold* upon Bodies; but in Winter they are leſs diſturb'd, and more at liberty to approach one another, and by ſhooting into thoſe *Chryſtals* (as we ſee the Particles of artificial Salts do, when the Liquor is expos'd to the the Air) which by both their Extremities inſinuating themſelves into the Pores of Particles of Water, make 'em cohere, and fix 'em in a ſolid Form. The Dimenſions of freez'd Bodies are encreas'd by the Inſinuations of theſe *Chryſtal* Wedges in their Pores, and the Particles of congeal'd Water are kept at ſome diſtance from one another, by the Figure of theſe *Chryſtals*, which in Freezing, inſinuate themſelves in their Pores; for as I have before ſaid, theſe *Chryſtals* are obſerv'd to have the Form of a double Wedge, whoſe Extremities are pointed and ſlender, but its Middle broader and larger, ſo that when the Extremities have inſinuated themſelves into the Pores of two watery Particles; theſe *Globules* cannot come to touch, by reaſon of the Largeneſs of the Middle of theſe *Chryſtals*, and ſo theſe Particles in Freezing, are kept at greater Diſtances from one another, than they were when in a fluid Form, and thus the Spaces between theſe ſpherical Particles become larger and wider than before, which is one Reaſon why Ice becomes *ſpecifically* lighter than Water. But beſides this, there are many little *Volumes* of Air included at ſeveral Diſtances, both in the Pores of the watery Particles, and in the Interſtices form'd by their ſpherical Figures. Now by the Inſinuation of theſe *Chryſtals*, the *Volumes* of Air are driv'n out of the watery Particles, and many of 'em uniting Form larger *Volumes*, which thereby have a greater Force to expand themſelves than when diſperſed, and ſo both enlarge the Dimenſions, and leſſen the *ſpecifick* Gravity of Water thus congeal'd into Ice. Hence we may gueſs at the manner, how Water impregnated with *Salts*, *Earths* or *Sulphurs*, which are not eaſily diſſolvible, may form itſelf into *Metals*, *Minerals*, *Gems*, and other *Foſſils*, the Parts of theſe Mixtures becoming a Cement to the Particles of Water, or getting into their Pores, change 'em into theſe different Subſtances.

Corollary

Hence it is plain, that the Quantity of Water on this our *Globe* does daily decreaſe, ſome part thereof being every Day turn'd into *Animal*, *Vegetable*, *Mineral*, or *Metallick* Subſtances, which are not eaſily diſſolv'd into their component Parts again; for ſeparate a few Particles of any Fluid, and faſten them to a ſolid Body, or keep 'em aſunder from one another, and they are no more fluid, to produce which, a conſiderable number of theſe Particles are neceſſarily required.

§ XXXII. *Mercury* ſeems to conſiſt of exceeding ſmall, ſmooth, ſolid, ſpherical or *ſpheroidical* Particles, for ſince *Mercury* in ever ſo ſmall Quantities is abſolutely opake, and lets none of the Rays of Light paſs; and ſince, whatever be the Cauſe of Reflexion and Refraction, Light being Material, muſt either make or find a Paſſage through every refracting *Medium*, ſince likewiſe it is probable, that Light does not paſs through the Subſtance of the conſtituent Particles of Fluids, but rather through the Vacuities form'd by their Orbicular Figures, it's plain, if the Particles of *Mercury* be ſpherical, that their Diameters are not much greater than thoſe of the Particles of Light, for theſe Interſtices are as the Cubes of the Diameters of the *Globules*, by whoſe meeting they are form'd, and ſeeing Light cannot paſs through theſe nterſtices, it is plain, that the Diameters of the Corpuſcles of *Mercury* muſt not be much greater than thoſe of Light; and if heſe Corpuſcles be *Spheriodical* or Oval, heir ſhorteſt Diameters muſt not be much greater than the Diameters of the Particles of Light, to form Paſſages for it. The Solidity of the Particles whereof *Mercury* conſiſts, and the ſmalneſs of the Interſtices they leave between them, accounts for that wonderful Gravity of *Mercury*, above other Fluids, and the extreme minuteneſs of its Particles for the eaſy aſcent of *Mercury* by Fire, beyond all other Fluids.

§ XXXIII. *Air* ſeems to conſiſt of *Spires* contorted into ſmall Spheres, through the Interſtices of which, the Particles of *Light* may freely paſs, and this is the Reaſon why it is ſo light, the ſolid Subſtance of the *Spires* being very ſmall in proportion to the Spaces they take up, their being ſpiral Accounts for the elaſticity of Air; their being ſpherical Particles which gives free Paſſage to any Heterogeneous Matter, Accounts for Airs being compreſſible, as alſo how when compreſs'd it retains its fluidity, becauſe ſpiral Spheres, through which another Matter freely paſſes, when compreſs'd, form themſelves into *Spheriods*, or Figures moſt reſembling them. This

Account of the properties of *Air*, may perhaps, pleaſe ſome; But there is another which to me ſeems the more genuine; for, if *Air* be ſuppos'd to conſiſt of ſmall Particles, which endeavour to recede from one another, with a Force *reciprocally proportional* to the Diſtances betwixt their Centers; all the Appearances of *Air* may thence be accounted for; for upon this *Hypotheſis* they will compoſe an *Elaſtick Fluid*, whoſe *Denſity* is proportional to its *Compreſſion*, as Mr. *Newton* has demonſtrated; *Prop.* 23. *Pag.* 301. The *Diameters* of the Particles of *Air* ſeem to be greater than thoſe of *Water*; and the *Diameters* of the Particles of *Water*, greater then thoſe of *Mercury*; and that of the *Light*, by far the leaſt of all, as ſhall be afterwards ſhown.

§ XXXIV. Other Fluids (beſides that of the *Light*, under which Name I comprehend all that which paſſes under the Name of *Ætherial* or *Subtile Matter*, which ſhall examin hereafter) ſeem to be compounded, of theſe *Primitive Fluids* viz. *Water*, *Air*, *Mercury* and *Light*; and of Particles of *Salts, Earths, Sulphurs*, and ſuch like Ingredients, and the Varieties of ſuch mixt Fluids may in the general be thus eſtimated. 1. Suppoſing all other things alike, eſpecially the *Primitive Fluid*, and the Figure of the parts of the Ingredient, the mixt Fluids will differ proportionably to the Magnitude of the parts of the ſolid Body, which mixes with the Fluid; thus Water or *Lymph* mix'd with *Globules* of Fleſh or Blood of a greater *Diameter*, will make a different Liquor from the ſame *Lymph*, mix'd with *Globules* of Fleſh or Blood of a leſs *Diameter*. 2. *Cæteris Paribus*, (eſpecially the Fluid, the Figure, and the Diameters of the mixing Ingredient being the ſame,) the Liquor will differ proportionably to the Difference of the Firmneſs or Softneſs of the Parts of the mixing Ingredient; thus *Mercury* mix'd with *Globules* of *Diamond*, would make a different Fluid from *Mercury* mix'd with *Globules* of Silver or Braſs. 3. All other things being ſuppos'd the ſame, the Fluid will differ proportionably to the Difference of the ſpecifick Gravities of the Particles of the mixing Ingredients; thus a mixture of *Gold* and *Mercury* will make a different Liquor from that of *Mercury* and *Lead*, the Difference of the ſpecifick Gravities being here only conſidered. 4. All other things being ſuppos'd the ſame, the Liquor will differ according to the different Degrees of the Coheſion of the ſolid Parts among themſelves; thus, *Mercury* mix'd with little ſpherical *Magnets*, will make a different mixture from that of *Mercury*, mixt with little Spheres of *Lead* or *Iron*. And theſe ſeem to be the *Primogenial* Differences of mixt Fluids; Now, not only all theſe may be differently combin'd with one another, and with the four *Primitive Fluids*, but alſo the Figures of the ſolid Parts in the mixture may be infinitely diverſified, (whereas we have hitherto only ſuppos'd all the mixing Solids *ſpherical*) which will make an infinitely infinite Variety of mixt Liquors.

§ XXXV. That *Light* is a Body, or a material Subſtance, ſeems to be evident from theſe Conſiderations. 1. It is progreſſive, and requires a determin'd time to go from one place to another, and is not propagated in an Inſtant, as is plain from Mr. *Romer*'s Reaſonings upon the *Eclipſes* of the *Satellits* of *Jupiter*, (which are confirm'd by the Obſervations of other *Aſtronomers*) whereby he demonſtrates that *Light* requires about ten Minutes to come from the *Sun* to us. 2. It may be ſtopt or reſiſted in its Paſſage from one place to another, by the Interpoſition of an opake Body, as other Fluids are ſtopt in their Courſes by the Oppoſition of any ſolid Body. 3. It may be congregated within a narrower, or ſcattered through a larger Space, as is evident from reflecting *Specula*, and refracting *Burning-Glaſſes*. 4. It may be reflected, and the Determination of its Motion changed like other Bodies, and it obſerves the ſame Law in its Reflexions that other Bodies do, *viz.* the *Angle* of Reflexion is always equal to the *Angle* of Incidence. 5. It may be put out of its Courſe more or leſs, according to the Nature of the *Medium*, through which it paſſes. 6. It acts upon the *Organs* of *Animals*, and upon all other Bodies, as other fluid Subſtances do, by ſtriking upon them with a determin'd Force, by communicating a certain Degree of Motion to them, by ſeparating their component Parts, and putting them in Motion; all theſe Effects we daily ſee. 7. It may be confin'd and ſhut up in determin'd Spaces like other Fluids. The The Light of the *Sun* will warm and heat other ſolid and fluid Bodies, which effects, continue when their Cauſe is remov'd; the parts of Light are yearly impriſon'd in Fruits, Plants, and other Vegetables, as we ſee by the Spirits, and warm Juices they afford. 8. Laſtly, the parts of Light are endow'd with various *Original Colours*, ſome are *Red*, others *Blue*, others *Yellow*, and ſome *Green*, as Mr. *Newton* has demonſtrated, and may be ſeen by a *Priſm* applied to the Hole of a darken'd Room through which the *Sun* ſhines. Now all theſe are the Properties of

Bodies and can belong to nothing but Material Subſtances.

§ XXXVI. That the Particles of *Light* are extremely little or ſmall, we may conclude from thence, that they paſs through almoſt all Bodies that are pervious, ſuch as *Chryſtals*, *Glaſſes*, ſeveral *Gems*, and almoſt all Fluids but *Mercury*, and that it freely paſſes where no other Fluid, how thin ſoever, can enter, and yet, no eye, however aſſiſted, has been able to diſcover or diſtinguiſh the parts of the groſſeſt Fluid. But what moſt of all demonſtrates their ſmalneſs, is that Light may be propagated from innumerable different *Luminous Bodies*, without any conſiderable oppoſition to one another; Suppoſe a Plate of Mettal (having at the top the ſmalleſt Hole can be made) were erected *perpendicularly* upon a *Horizontal Plane*, and about it were ſet innumerable luminous Objects of about the ſame height with the Plate, at an ordinary Diſtance from it, the Light proceeding from every one of thoſe Objects, will be propagated through this ſmall Hole, without interfering

ring. This will appear by applying a dark Object, in a ſtraight Line againſt the Luminous Body, for the Light of this Body will through the Hole be receiv'd upon the dark Body; Now it is impoſſible that ſo many different *Streams of Light* cou'd be tranſmitted through ſo ſmall a Hole, were not the Particles of Light extremely ſmall. Add to this, that were not the Particles of Light extremely little, being extremely ſwift, (*i. e.* more than a Million of times ſwifter than a *Cannon Bullet*, continuing in its greateſt Velocity, as ſhall be preſently ſhown) they wou'd peirce all kinds of ſolid Bodies with almoſt as great Facility as they do Vacuities, whereas we ſee Light regularly reflected from ſome Bodies. Moreover, we find that innumerable different Spheres of Light within our *Horizon*, may be propagated from their ſeveral luminous Centers, without interfering. How many Millions of Candles and *Flambeaux* may we ſee ſending out their *Tides* of Light, without claſhing upon one another, which argues both the Smallneſs of the Parts of Light, and the Largeneſs of the void Interſtices between the Particles of Air and other Bodies.

§ XXXVII. How extremely ſwift the Particles of *Light* are, we may gather from the forementioned Experiment of Mr. *Romer's*, whereby he demonſtrates, that the *Streams* of *Light* paſs from the *Sun* to our *Earth* in about ten Minutes; and *Hugens* in his *Coſmotheoros*, has prov'd, that a *Bullet* continuing in the Velocity with which it leaves the Muſle of the *Cannon*, wou'd require twenty five Years to paſs from us to the *Sun*; Now the *Via Percurſa* being the ſame in both, the Velocities will be reciprocally as the times, *i. e.* the Velocity of Light will be to that of a *Cannon-Bullet*, perſiſting in its greateſt ſwiftneſs, as twenty five Years is to ten Minutes, or as 1314700 to one *Proxime*, ſo that the Velocity, with which the Particles of Light paſs, will be more than a Million of times ſwifter than a *Cannon-Bullet*. Moreover, the Diſtance betwixt the *Sun* and *us* is at Leaſt 12000 *Diameters* of the Earth, but allowing it to be only 10000 *Diameters*, the Light runs a thouſand *Diameters* in a Minute, or ſixteen and half Diameters of the Earth in a Second, or beating of an Artery, that is more than 1100000 *Toiſes*, ſince the *Diameter* of the Earth contains 2865 *French Leagues*, and every *League* contains 2282 *Toiſes*, according to the Numbers of Mr. *Picard*. But Sound goes but about 180 *Toiſes* in a Second, wherefore Light is about ſix hundred thouſand times more Swift than Sound. Likewiſe ſince the Earth's middle *Diameter* is 7846 Miles, each of which contains 5000 Feet; and ſince Light goes in a Second or in a pulſe of an Artery, ſixteen and a half; *Diameters* of the Earth, it is plain, that in every Second it runs at leaſt a hundred and thirty thouſand Miles, which is a prodigious and almoſt an incredible Space in ſo ſhort a time. But the extraordinary Effects of Light and Heat ſeem to require all this; we ſee how powerfully it acts (being congregated) upon the moſt compact ſolid Bodies, and we never perceive any diminution of its Force ariſing from an abatement of its Velocity.

§ XXXVIII. The *Sun* and fixt *Stars* ſeem to be huge, denſe Bodies (like the *Earth* or *Planets*) heated to an extraordinary Degree, and their Heat probably may be preſerv'd by the greatneſs of their Bodies, and the mutual Action and Re action between their Parts and the Light, which they emit, and their Parts are kept from fuming away by their *fixity*, and alſo by vaſt Weight and Denſity of the *Atmoſpheres* incumbent upon them, and powerfully compreſſing them, and condenſing the Vapours and Exhalations which ariſe from them: The Light ſeems to be emitted from them by the vibrating Motion of their Parts, after the manner we ſee Iron, when heated to ſuch a Degree, as to be juſt going into Fuſion, by the vibrating Motion of its Parts, ſend forth with Force and Violence, copious Streams of liquid Fire all around; Great Bodies preſerve their Heat longeſt, and that perhaps in proportion to their *Diameters.* Mr. *Newton* has made it probable, that the *Comet* which appear'd in 1680. by approaching to the *Sun* in its *Perihelium*, acquir'd ſuch a Degree of Heat, as to be 50000 Years a cooling, whence we may gueſs, that ſuppoſing the *Sun* and fixt *Stars* to be only *Collections* of denſe and ſolid Matter like the *Planets*, heated to a very intenſe Degree, they may be many Millions of Years without loſing any conſiderable part of their Heat. *Aſtronomers* have obſerv'd a cloſe, compact and large *Atmoſphere* about the *Sun*, and there is no doubt to be made, that its Body is of the ſame Nature with the other material Parts of this Univerſe, excepting what Alterations its vehement Heat may produce, and conſequently, its highly probable, that the *Sun* and *fixt Stars* are only *Planets*, vehemently heated.

§ XXXIX. *Bodies* and *Light* act mutually upon one another, *i. e. Bodies* act upon *Light*, in emitting reflecting, refracting and bending its Rays, and *Light* upon *Bodies*, in heating them, and putting their

Parts in a vibrating Motion, wherein Heat conſiſts, according to Mr. *Newton*'s Diſcoveries. If we ſuppoſe that *Bodies* act upon *Light*, by attracting it in Lines *perpendicular* to their Surfaces, *i. e.* ſuppoſing two ſimilar *Mediums* diſtinguiſhed by *Parallel* Lines, and that a Ray in its Paſſage out of the one through the other, is urged *perpendicularly* towards either Plane, by any Force, which at given Diſtances from the Plane, is of given Quantities; then whatever Inclinations the Rays have to the Plane of *Incidence*, the Sign of the *Angle* of *Incidence* of every Ray conſidered apart, ſhall have to the Sign of the *Angle* of *Refraction* a conſtant *ratio*; this Mr. *Newton* has demonſtrated, both in his *Principia*, pag. 227. *& ſeq.* and in his *Opticks*, pag. 57. *& ſeq.* and if the Velocity of the Ray be greater before its *Incidence* than afterwards it ſhall be reflected, and the *Angle* of *Incidence* ſhall always be equal to the *Angle* of *Reflexion*; and ſince it is Matter of Experiment and Obſervation, that the Signs of the *Angles* of *Incidence* and *Refraction* in all Rays of whatever Nature, obſerve a conſtant *ratio*, and that the *Angles* of *Reflexion* and *Incidence* are equal; it is therefore on the other hand true, that the Rays of *Light* are thus urg'd by the *Refracting Media*, and their Velocity thus abated by *reflecting* ones, ſo that it is evident, *Refraction* and *Reflection* proceed from one and the ſame Princiciple, acting differently in different Circumſtances.

§ XXXIX. Mr. *Newton* has demonſtrated from plain and convincing Experiments, that the *Light* of the *Sun* conſiſts of Rays differently *refrangible* and *reflexible*, and that thoſe Rays are differently *reflexible*, that are differently *refrangible*. Theſe Rays hat are all alike *refrangible*, he calls the *Light* of them Simple and *Homogeneal*, and thoſe hat are ſome more *refrangible* than others, e calls their *Light*, Compound and *Heterogeneal*; the greater or leſs *Refrangibility* of Rays, is their Diſpoſition to be turn'd more or leſs out of their way, in like Incidences on the ſame *Medium*; and their greater or eſs *Reflexibility* is their Diſpoſition to be return'd back more or leſs eaſily into the ſame *Medium* from any other, upon whoſe Surface they fall. *Refraction* out of the Rarer *Medium* into the Denſer is made ſo, that the *Angle* of *Refraction* is leſs than the *Angle* of *Incidence*, and on the contrary. The Colours of *Homogeneal Light* are theſe, *Violet, Indico, Blue, Green, Yellow, Orange* and *Red*. Theſe Colours in the Objects are their Diſpoſition to *reflect* this or that ſort of Rays more copiouſly than the reſt; and in the Rays of *Light* they are their Diſpoſition to propagate this or that Motion into the *Organs* of Viſion, and in *them*, they are Senſations of thoſe Motions under the Forms of Colours; the Rays that produce Red Colours, are leaſt *refrangible*, and thoſe that make Violet, the moſt, and the reſt are more or leſs *refrangible*, as they approach either of theſe Extremes in the Order ſet down, that is, Orange is leaſt *refrangible*, next to Red, and Yellow next to Orange, and ſo on. All the Colours of the Univerſe which are made by Light are either the Colours of *Homogeneal* Lights or compounded of a Mixture of thoſe; Whiteneſs is produc'd by a due Mixture of all the *Primary* Colours of *Homogeneal* Light; and Blackneſs by a Suffocation, or *Non-reflexibility* of Light; and all Grey Colours, betwixt Black and White, may be compounded of all the *Primary* Colours mixt in a due Proportion; the *Primary* Colours of *Homogeneal* Light are unchangeable in their Nature, and no *Reflexions* nor *Refractions* will change any of theſe into another; whereas by the due Mixture of colour'd Bodies, Colours may be produc'd by Compoſition, which ſhall be like to the Colours of *Homogeneal* Light, but not as to the immutability of Colour; for that may be chang'd according to the Colour of the Light by which they are ſeen; ſo that if the *Sun's* Light conſiſted but of one ſort of Rays, there wou'd be but one Colour in the whole World, and it wou'd be impoſſible to produce any new Colour by *Reflexions* or *Refractions*, for all the Variety of Colours depends upon the Compoſition of Light.

§ XL. The Rays of Light which fall upon Bodies and are *reflected* or *refracted*, begin to bend before they arrive at the Bodies. Mr. *Newton* has ſhown by ſeveral Experiments of Rays paſſing by the Edges of Bodies, that they are *incurvated* by the Action theſe of Bodies as they paſs by them, and that this Action is ſtrongeſt at the leaſt Diſtance; he has demonſtrated likewiſe, that the Cauſe of *Reflexion* is not the impinging of Light on the ſolid and impervious Parts of Bodies. For (not to repeat thoſe other Arguments which he has brought in great plenty) ſince Glaſs can be no other ways poliſh'd than by grating and ſcratching it by Subſtances, whoſe Parts are ſmall and ſubtile, ſo that the Scratches and Frettings of its Surface become too ſmall to be viſible, yet not ſo ſmall as to become truly plain or *ſpherical*, and all together to compoſe one Surface; if Light were *reflected* by impinging upon the ſolid Parts of Glaſs; it wou'd be ſcatter'd as much by the moſt poliſh'd Glaſs, as by the rougheſt, which being contrary to Experience, it is evident that the Reflexion of a Ray is not effected by one ſingle Point of the *reflecting* Body, but by ſome Power of the Body, which is evenly diffus'd over all its Surface, by which it acts upon the Ray without immediate *Contact*, after the manner hinted § 37. Bodies *reflect* and *refract* Light by one and the ſame Power variouſly exerciſed in various Circumſtances; for when Light goes out of Glaſs into Air as *obliquely* as it can poſſibly do, if its *Incidence* then be made ſtill more *oblique*, it becomes totally *reflected*, for then its *refractive* Power, or the Force of its Attraction upon the Ray, becomes too ſtrong to let any of the Rays go through. Beſides that, thoſe Surfaces of tranſparent Bodies which have the greateſt *refracting* Power, *reflect* the greateſt Quantity of Light; for by Experiment it is found, that in the *Superficies* interceding two tranſparent *Mediums*, the *Reflexion* is ſtronger or weaker, as the Superfice hath a greater or leſſer *refracting* Power, for in the confine of *Air* and *Sal-Gem* 'tis ſtronger than in the confine of *Air* and *Water*, and ſtill ſtronger in the confine of *Air* and *common Glaſs* or *Cryſtal*, and ſtronger in the confine of *Air* and *Diamond*. Between the Parts of opake and colour'd Bodies, there are many Spaces either empty or repleniſh'd with *Mediums* of other Denſities, as Water between the tinging Particles wherewith any Liquor is impregnated, Air between the *aqueous Globules*, that conſtitute Clouds or Miſts, and perhaps, *Mediums* different from both theſe between the Parts of hard Bodies. Now *Reflexions* are produc'd in the *Superficies* which intercede theſe *Mediums* of different Denſities, and the Reaſon why uniform, pellucid *Mediums* have no ſenſible Reflexion, but at their external *Superficies*, is becauſe all their Parts are of an equal Denſity; and Opacity ariſes from the multitude of *Reflections* produc'd in the internal Parts of Bodies.

§ XLI. All Bodies ſeem to have their *refractive* Powers *proportional* to their Denſities, excepting ſo far as they partake more or leſs of ſulphurous, oily Particles, and thereby have their refractive Power made more or leſs; this Mr. *Newton* has found by Obſervation on almoſt all tranſparent Bodies, together with a Calculation founded upon the Suppoſition, that Light is ſwifter in Bodies than *in vacuo*, in the Proportion of the *Signs* which meaſure the *Refraction* of Bodies, which is certainly true, ſince it's from the Action of Bodies on Light, that this *refractive* Power does ariſe; and it's very probable, that this *refractive* Power in Bodies does moſtly depend upon the ſulphurous Parts with which they abound, ſince all Bodies partake more or leſs of Sulphurs, as by Chymical *Analyſes* we find. And as Light congregated by a Burning-Glaſs, acts moſt upon ſulphurous Bodies, to turn them into Fire and Flame; ſo ſince all Action is mutual, Sulphurs act moſt upon Light: and that the Action between Light and Bodies is mutual, is evident from this Conſideration, that the denſeſt Bodies which *refract* and *reflect* Light moſt ſtrongly, grow hotteſt in the Summer Heat, by the Action of the *refracted* and *reflected*

Light. The Bodies that reflect Light, are thoſe whoſe Pores are fill'd with *Mediums* of an unequal Denſity with that of the *refracting Medium* itſelf, and Bodies become more tranſparent, by filling their Pores with Fluids of equal, or almoſt equal Denſities with their Parts, as Paper dip'd in Water or Oyl; and on the contrary, the moſt tranſparent Subſtances may by evacuating their Pores, or ſeparating their Parts, be rendered ſufficiently opake, as Salts or wet Paper dried, Glaſs by being pulveris'd, or Horn by being ſcrap'd.

XLII. The *leaſt Parts* of almoſt all Natural Bodies are tranſparent, as may be ſeen by viewing ſmall Bodies with a *Microſcope*, and conſequently, they muſt according to their ſeveral Sizes, reflect Rays of one Colour, and tranſmit thoſe of another, upon the ſame Ground that thin Plates reflect or tranſmit thoſe Rays; for a thin Plate of an even thickneſs appears all over of the ſame Colour, and if this Plate were ſlit into *Threads*, or broken into *Fragments* of the ſame thickneſs with the Plate, there is no Reaſon why every *Thread* or *Fragment* ſhould not keep its Colour, and conſequently, why a heap of thoſe *Threads* or *Fragments* ſhould not conſtitute a Maſs or Powder of the ſame Colour which the Plate exhibited before it was broken; and the ſmall Parts of all Natural Bodies being like ſo many *Fragments* of a Plate, muſt on the ſame Grounds exhibit their Colours. Now Mr. *Newton* found by Obſervation, that thin Plates or Bubbles *reflected* Rays of one Colour and *traſmitted* thoſe of another, according to their ſeveral thickneſs or thinneſs; and therefore the ſmall Parts of Natural Bodies being tranſparent, muſt upon the ſame Grounds *reflect* or *tranſmit* the ſeveral ſorts of Rays: and this is the Foundation of the various Colours of all Natural Bodies. But the parts of Bodies on which their Colours depend, muſt be denſer than the *Medium*, which pervades their Interſtices; and as there is a conſtant Relation between Colours and *Refrangibility*, the moſt *Refrangible* Rays being *Violet*, the leaſt *refrangible*

Red, and thoſe of intermediate Colours having proportionally intermediate Degree of *Refrangibility*; ſo there is a conſtant Relation between Colour and *Reflexibility*, th *Violet* being in like Circumſtances reflected at leaſt thickneſſes of any Plate or Bubble the Red at greateſt thickneſſes, and the intermediate Colours at intermediate thickneſſes and there are ſeveral Orders of thoſe Colours more or leſs intenſe and vivid, according to the ſeveral thickneſſes of theſ Plates or Bubbles: and the Reaſon why th Surfaces of all thick and tranſparent Bodies reflect part of the Light incident o them, and refract or tranſmit the reſt, is that ſome Rays at their *Incidence* are in *Fit* of eaſie *Reflection*, and others in *Fits* o eaſie *Tranſmiſſion.* Thoſe whoſe who deſire full Satisfaction in this wonderful Appearance of Nature, muſt go to that late admirable Treatiſe of *Opticks*, written by Mr. *Newton*; for it is impoſſible to ſeparate the Parts of this Work from one another without Diſadvantage to them, or to ſum them up in a leſs room, without loſing ſome-

thing

hing *New* and *Uſeful.* That great Perſon having before ſhown how far *Numbers* and *Geometry* would go in *Natural Philoſophy*, has now manifeſted to the World to what ſurprizing Heights, even vulgar *Experiments* duly managed and carefully examined in ſuch Hands may advance it. In the general, I think we may ſafely conclude from Mr. *Newton*'s Diſcoveries, 1. That the *Sun* and *fixt Stars* are but *Planets* or *Earths* vehemently heated, or having their ſmalleſt Parts put in a ſtrong *vibrating* Motion. 2. That Light is emitted from them, by theſe powerful *Vibrations* of their ſmalleſt Parts. 3. That this Fluid of Light emitted from theſe *vibrating* luminous Bodies requires a certain time in paſſing from them to us, and moves after the ſame manner other Fluids do, only with a much greater Velocity. 4. That Bodies draw this Light to 'em in Lines *perpendicular* to their Surfaces, and that this Light puts the parts of theſe Bodies in a *vibrating* Motion wherein Heats conſiſt. 5. That the Motion of Light is ſwifter in Bodies than

in vacuo, by reaſon of this Attraction, an
and ſlower after its being *reflected*, than i
its *Incidence*, becauſe that Force of Attra
ction which accelerates its Motion in it
Incidence, muſt of Neceſſity retard its Mo
tion in its *Reflexion*, by reaſon of the diffe
rent Direction thereof. 6. That the Ra
in its whole Courſe of *Reflexion* and *In*
cidence deſcribes a *Curve*, or is rather bend
ed than broken. 7. That the *Vibratio*
of the ſmaller Parts of Bodies produc'
by the Action of Light, when brough
to a certain Degree of Strength, is th
Cauſe of their Light, juſt as we ſee th
Vibrations produc'd in the Air by tremulous and ſonorous Bodies, muſt be o
ſuch a determin'd Force to produce a diſtinct Sound. 8. That theſe *Vibration*
produc'd in Bodies by the Action o
Light, when their Motion conſpires with
that of the Rays of Light, *i. e.* when
any Ray is in that part of theſe *Vibrations*
that has the ſame Direction with that of
the Ray, it eaſily breaks through a *refracting* Subſtance, but when it is in the
con-

contrary part of the *Vibration*, which impedes its Motion, it is eaſily reflected, and ſo every Ray is diſpos'd *alternately* to be eaſily *reflected* or eaſily *tranſmitted*. 9. That he Rays of Light are of their own Na-ure diverſly *Refrangible* and *Reflexible*, and hat this diverſity in both ariſes from the ſame Principle, acting differently in different Circumſtances, *viz.* the Action of Bodies upon Light. 10. That *Reflexion* s caus'd by the different Denſities of Bodies, and happens only in *Superficies* that ntercede *Mediums* of different Denſities. 11. That Light is totally tranſmitted hrough *Mediums* only that are of the ſame uniform Denſity, and that the *refractive* Power of Bodies is principally owing to he Sulphurs with which they abound; or ſince all Action is mutual, and ſince Light congregated by a Burning-Glaſs acts moſt upon Sulphurs, ſo Sulphurs ought to act moſt upon Light. 12. That the Forces of Bodies to *reflect* or *refract* Light are very nearly proportional to the Denſities of the ſame Bodies. 13. That certain Colours are ty'd to ſuch Degrees of *Refrangibility* or *Reflexibility*, and that all the *primitive* and *original* Colours depend upon theſe Degrees. 14. That *White* conſiſts in an equal Mixture of all the *primitive* Colours, and *Black* in a Suffocation of all the Rays of Light, which is the Reaſon why *Blacks* burn more eaſily than other Colours; and other not *primitive* Colours ariſe from a certain Mixture of theſe. 15. That the Colours of Natural Bodies depend upon the different Denſity of their ſmall Parts, and thereby their fitneſs to reflect Light of one Colour and tranſmit that of others. 16. That ſeveral ſorts of Rays make *Vibrations* of ſeveral bigneſſes, which according to their bigneſſes excite Senſations of ſeveral Colours much after the ſame manner, that the *Vibrations* of the Air according to their ſeveral bigneſſes excite Senſations of ſeveral Sounds. 17. That the *Harmony* and *Diſcord* of Colours ariſe from the Proportions of the *Vibration* propagated through the Fibres of the Optick Nerves into the Brain, as the *Har-*

nony and *Diſcord* of Sounds ariſes from the roportions of the *Vibrations* of the Air.

Corollary.

From what has been ſaid of the Nature of the *Sun*, and its *Light*, it is evident that he Quantity of Heat and Light in the *Sun* does daily decreaſe; like other vehemently hot Bodies it muſt gradually cool; as alſo, by its *Emiſſion* of ſo many Millions of Rays perpetually, quite round its Body upon all he *Planets* within its Syſtem, which do not eturn, both its Bulk and Heat muſt be diminiſhed. It is not improbable that all the virtual Heat in the juices of Vegetables, Metals and Minerals, may be owing to the mpriſoned Rays in 'em; the Production of Animals in the ordinary way, require sa certain Degree of Warmth, which proceeds from his Influence. Some Bodies do ſtifle and ſuffocate the Rays of Light, ſo as that they are never, or not duly reflected again. Sulphurous Bodies form little Cells by the Action of the Rays of Heat and Light to retain 'em, and from the Ingenious Experiment of the *accurate* and *learn'd* Mr. *John Bernoulli*, we are inform'd, that our *Atmoſphere* and all the Bodies on our Globe are *ſaturated* at all times with Rays of Light which never return again to their Fountain, becauſe as has been ſhown in the former Sections, Bodies do attract, and conſequently retain theſe Rays. I ſhall here ſet down one of the Ways (for he try'd the ſame Experiment after different manners) the Ingenious Author preſcribes, which by my Order was repeated here at *London*. They are related in the 2d. Volume of Mr. *Fontanelle*'s *Memoirs of the Academie Royalle for the Year* 1700. We ſuck'd thro' a very clean Tube of about 30 Inches in Length, open at both ends, very well cleanſed *Mercury*, till it came to the top, then nimbly ſtriking off the upper Surface of the *Mercury*, which had been ſoil'd by the Air, and hindred the Effect in former Tryals, we nicely and quickly clos'd the upper end with a proper Cement ſo that no Air cou'd get in, then ſuſpending the Tube that the *Mercury* might ſubſide, and darkening the Room that no Light could get in, we perceiv'd that at every *Vibration*, Flaſhes of Light appear'd in the Vacuity at the upper End, which enlighten'd all the Room, which as Mr. *Bernoulli* reaſons, happen'd thus; that Film of Dirt, wherewith the Air ſoils the upper Surface of the *Mercury*, and which hinders the Paſſage of the Particles of Light in ordinary *Barometers*, being remov'd; in the *Vibrations* of the Tube, the *Mercury* aſcending in its oblique Situation, ſubſides again in its *Perpendicular* one, and thereby leaves behind it a Vacuity, to fill which, the Particles of *Light*, being the only Body that can get in, ruſhes in, from the *Mercury* and through the Glaſs, in great Quantities, and ſo produces theſe Flaſhes; which ſhows hat the Subſtance of *Light*, is ſcattered every where, though it be not viſible. Now ſince it's certain, that Bodies do attract he Rays of *Light*, and do retain 'em ſo, hat they can never return to the Fountain of *Light* again; it's plain, the Quantity of *Light* both in this *Bright Luminary*, and in the *Sun like fixt Stars* muſt be continually decreaſing: However, it's alſo certain, that this Decreaſe is very inconſiderable in any ſhort time, though we are ſure there is ſome, and our not being ſenſible of this Decreaſe, is only an Argument of the exceeding Smalneſs of the Particles of *Light*. We find ſome *odoriferous* Bodies, ſend out Steams for many Years, without ſenſibly diminiſhing either their Bulk or Weight, which argues the Smalneſs of the Parts of theſe Steams. But the Particles of *Light* muſt be extremely ſmall, ſince the *Sun* for ſo many Ages has been conſtantly emitting *Oceans* of Rays, without any ſenſible Diminution: But this can ſurpriſe no Body, who conſiders that Matter is infinitely diviſible; for it is poſſible to aſſign in Numbers, a Quantity whereof a Body as big as the *Sun* may conſtantly, for any finite Number of Years emit *Oceans*, and yet the Sum of 'em all may not be greater than a cubical Inch or even a Grain of Sand.

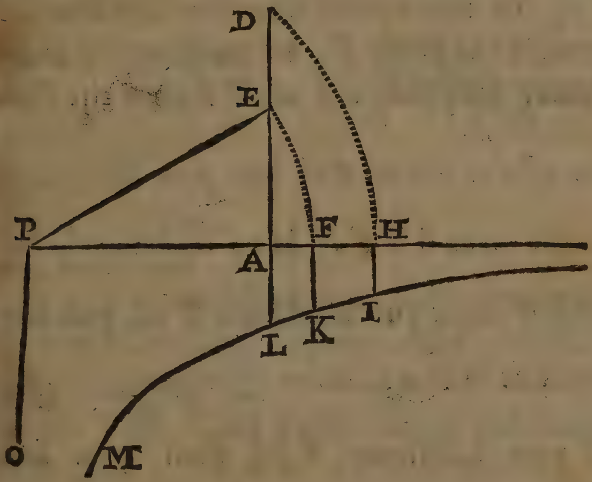
§ XLIII. We have already obſerv'd, that the moſt general Condition, of the *Univerſal Law* of Gravitation in Bodies, was, that at the ſame Diſtance from the Center of the attracting Force, Bodies did gravitate in proportion to their Solidity, and at different Diſtances, *reciprocally* as the Squares of thoſe Diſtances; but this Condition is not ſo general, as altogether to exclude others; the way to know how this *Univerſal Law* is diverſify'd, in the different Bodies, is to obſerve what Lines, Bodies n their Motions or Actions upon one another deſcribe, or what the Effects of theſe Motions and Actions are; and then to inveſtigate what Conditions of the *Univerſal Law* of Gravitation, will make Bodies deſcribe theſe Lines, or produce theſe Effects. Thus if any of the *Primary* or *Secondary Planets*, did deſcribe perfect Circles or *Ellipſes* about the *Sun*, or a *Primary Planet* plac'd in the Center, the Condiion of the *Univerſal Law* in theſe, would be, that the *attractive Force* at different Ditances from the Center, would be as theſe

Diſtances directly. If they deſcribed a *Parabola*, by ſuppoſing the *attractive Force* at an infinite Diſtance, or an *Hyperbola*, by changing the *Centripetal* into a *Centrifugal Force* ; then the Condition of the *Univerſal Law* wou'd be, that the Force were always *equable* and the ſame at all Diſtances, as Mr. *Newton* has demonſtrated, *Prop.* 11. *Lib.* I. We find, as has been inſinuated in the preceding Sections, That the Rays of *Light* in paſſing through different *Media*, do tend *perpendicularly*, to either the Plane of *Incidence* or *Reflexion*, ſo that the Force of Attraction is always the ſame, at equal Diſtances from the ſame Plane. We ſee that the Parts of *Air*, ſhun or fly from one another, inſtead of tending to one another ſo that in accounting for the Appearances of Nature from the *Univerſal Law* of Gravitation, we are not ty'd to one ſingle Condition, but may have recourſe to others as the Nature and Neceſſity, of the Appearances ſeem to require; for the whole Difficulty of *Philoſophy*, ſeems to lie in inveſtigating the Powers and Forces of Nature from the Appearances of the Motions given, and then from theſe Powers to account for all the reſt.

§ XLIV. The obvious Appearances of *cohering* Bodies are thus, two very ſmooth well poliſh'd, plain Bodies, put together, will firmly cohere even in an exhauſted Receiver, which ſhows evidently that their *Coheſion* is owing, neither to the Gravity, nor to any other Property of the Air; all ſaline, cryſtalline, and moſt mineral Bodies, break in very ſmooth and plain, or at leaſt *congruent* Surfaces; and univerſally almoſt all hard and very compact Bodies, break with Surfaces, which immediately upon the Separation, appear whitiſh, which is an Evidence, that though the Surfaces be very ſmall, yet they are very ſmooth and poliſh'd, for only innumerable little poliſh'd Surfaces, are fit to reflect plentifully ll kinds of Rays, whereby white Coours are produc'd. Now theſe Appearances of *cohering* Bodies, do naturally lead us o imagine, that one neceſſary Condition oward *Coheſion*, is the plainneſs, or at leaſt

Congruity of *cohering* Surfaces, and this ſeems neceſſary to exclude any Fluid from lying between *cohering* Bodies, for theſe Bodies cannot be ſaid to *cohere*, or be continued, betwixt whoſe *cohering* Surfaces, in all its Points a Fluid may inſinuate itſelf. The plainneſs and ſmoothneſs of the *cohering* Surfaces, will make more Points come into *Contact*, than when they are rough and irregular. For whatever Cauſe *Coheſion* ariſes from, if we ſuppoſe that Cauſe to act moſt ſtrongly at the *Contact*, the more Points of the *cohering* Bodies come into *Contact*, the firmer the *Coheſion* will be; and though exact Congruity in *Curve* Surfaces, will bring as many Points into *Contact*, as plain Surfaces will, yet *Curvity* not being the ſimpleſt, nor moſt expeditious Method of producing this Effect, neither agreeable to Nature, (who always brings about all her Effects the ſhorteſt and eaſieſt way) it ſeems evident, that the plainneſs and ſmoothneſs of Surfaces, is one Condition of *Coheſion*, and that thoſe *Atoms* that are terminated with plain Surfaces, will (*cæteris paribus*) produce Bodies of the firmeſt *Coheſion.* This will appear more evident from the contrary Quality in the conſtituent Particles of Fluids. For we have ſhown before, that one neceſſary Condition of *Fluidity*, is the *Curvity* of the Surfaces, of the conſtituent Particles of Fluids, whereby their *Coheſion* is very ſmall, in reſpect of the *Coheſion* of thoſe Particles that are terminated with plain Surfaces, and their Gravity always exceeds the Force of their *Coheſion*, ſo that from both theſe Cauſes, they eaſily ſlip and move one upon another. We may then ſuppoſe that ſome of the *Primary Atoms*, of which Bodies are conſtituted, are terminated with plain Surfaces on all ſides, which will produce Bodies of the firmeſt *Coheſion*, others are partly terminated with plain, and partly with *curve* Surfaces, which will produce Bodies of a mean *Coheſion*; others again are intirely terminated with *curve* Surfaces, which will produce Fluids, and between thoſe intirely plain, and entirely *curve*, there are infinite *Combinations*, of plain and *curve* Surfaces which will account for all the various Degrees of *Coheſion* in Bodies, in reſpect of their Figures. But though this ſmoothneſs and plainneſs, in the Surfaces of *cohering* Bodies, will bring moſt Points into *Contact*, yet this will not hinder them from being ſeparated, by any Force how ſmall ſoever; and ſince we are certain, that *cohering* Bodies require a determin'd Force, to ſeparate them, there wants ſtill a *Cement*, as it were, to hinder them from being eaſily ſeparated when join'd. Now this can be deriv'd from nothing in Nature, but that *Univerſal Law* of Attraction, whereby all the Parts of Matter, endeavour to *embrace* one another, and cannot be ſeparated but by a Force ſuperiour, to that by which they attract one another; let us then enquire what Condition of the *Univerſal Law*, will moſt fitly anſwer the Appearances of *Coheſion*.

§ XLV. On the Center *A*, and at the Diſtance *AD*, let a Circle be deſcribed, to whoſe Plane at *A*, let *P A* be *perpendicular*, and *P* be a *Particle* of Matter, attracted by all the Particles of this Circle, in any Condition of the *Univerſal Law*, from *P* to any any Point in the *Radius* of the Circle draw *P E*, in the right Line *P A*, take



PF = *P E*, and at *F* draw *F K* paallel to *A D*, of ſuch a length as may epreſent the Force whereby, the Particle *E* ttracts the Body *P*, and let *L K I* be the *urve* which the Point *K* thus conſtantly ircumſtantiated Generats; Mr. *Newton* has lemonſtrated, *Pag.* 218. *Prop.* 90. *Lib.* I. *Princip.*

Princip. Phil. Mathemat. that the Force whereby the whole Circle, upon the *Radiu* *AD*, attracts the Corpuſcle *P*, is as the *AHIL* multiplied upon the Diſtance *AP*. let *PF* be call'd *x*, and *FK*, *y*; and le *FK*, or the Force whereby the Point *F* attracts the Body *P*, be reciprocally as any Power (ſuppoſe *n*) of *PF* then the *Equation* of the *Curve* will be, $y = \frac{1}{x^n} = x^{-n}$ whoſe *Area* $OPFKM = \frac{x^{1-n}}{1-n} = \frac{1}{\overline{1-n}\; x^{n-1}}$ And if for x you ſubſtitute PA, you have the *Area* $OPALM = \frac{1}{\overline{1-n}\;\overline{PA}|^{n-1}}$. If for x you ſubſtitute PH, then you have $OPHILM = \frac{1}{\overline{1-n}\;\overline{PH}|^{n-1}}$, and therefore putting $m. = n - 1$, we ſhall have, $AHIL =$ $OPHILM - OPALM = -\frac{1}{m}$ $\times \frac{1}{\overline{PH}|^{n-1}} \overset{1}{\times m} - \frac{1}{\overline{PA}|^{n-1}} = \frac{1}{m \times \overline{PA}|^{n-1}}$

$- m$

$-\frac{1}{m \times \overline{PH}|^{n-1}}$, and conſequently the *ttraction* of the Circle upon the *Cor-*

uſcle $= PA \times AHIL = \frac{PA}{m \times \overline{PA}|^{n-1}}$

$$-\frac{PA}{m \times \overline{PA}|^{n-1}} = \frac{1}{m \times \overline{PA}|^{n-2}}$$

$$-\frac{PA}{m \times \overline{PH}|^{n-1}}$$

If $n = 1$. and $PA = 0$, then the *Radius* f the attracting Circle being produc'd, will coincide with the *Aſymptote* PO, in which Caſe, (the *Curve* being the vulgar *Hyperbola*,) the *Area* $AHIL$ will be in-inite, and PA being nothing, or the Di-tance between the *Corpuſcle* and the *at-racting Plane* vaniſhing, the *Attraction* $PA \times AHIL = 0 \times \infty = 1$.

If $n = 1$ and $PA = \infty$ *i. e.* when the attracting *Plane* AD, is plac'd at the *Con-courſe* of the *Hyperbola*, with its *Aſymptote* PH, then the Arch DH (whoſe Center is P, and whoſe *Radius* is $PD = PA = \infty$.) will coincide with AD, and conſequently AL and HI will coincide, and therefore $PA \times AHIL = \infty \times 0 = 1$.

If $n = i$ and $PA = a$, let AH be called y, then $PH = x = a + y$. And the *Attraction* of the Circle upon the *Corpuſcle* $PA \times AHIL = y - \frac{y^2}{2a} + \frac{y^3}{3a^2} - \frac{y^4}{4a^3}$ &c.

If $n = 2$. and $PA = 0$, then the *Area* $AHiL$ will be *more than Infinite* (the meaning of which Expreſſion ſhall be afterwards explain'd) and therefore the Attraction will be $PA \times AHIL = 0$ multiply'd into more than Infinite; from whence it appears that the Force of the *Attraction* in this Caſe, when $PA = 0$, is greater than that in the former Caſe, where $n = 1$. and $PA = 0$.

If $n = 2$ and $PA = \infty$, there the *Area* $AHIL$ will be nothing, and conſequently the *Attraction* $= PA \times AHIL = \infty \times 0 = 1$: And hence it appears that in n this Caſe, if *P A* $= o$, the *Attraction* will e greater than when *P A* $= \infty$. for of wo Products, having the ſame Multipli-ator, that is the greater, which has the greater Multiplicand, ſo that if *A* denote he *Attraction*, when *P A* $= o$ and *a* the *Attraction*, when *P A* $= \infty$, I ſay, that *A* is o *a*, as a greater than infinite is to infinite, contrary to what happen'd in the firſt Caſe, where $n = i$, for the *Attraction* in that Caſe was the ſame both when *P A* was equal to *o* and to ∞, *viz* 1.

If $n = 2$ and *P A* $= a$, then as formerly *A H* being call'd *y*, the *Attraction* $=$ *P A* $\times$ *A H I L* $= \frac{y}{a} - \frac{y^2}{a^2} + \frac{y^3}{a^3} - \frac{y^4}{a^4} + \frac{y^5}{a^5}$, &c.

If $m = 3$ and *P A* $= o$, then *A H I L* will be more than infinite, but *A H I L* in this third Caſe will be greater than *A H I L* in the ſecond Caſe, and conſequently the Force of the *Attraction* when *P A* $= o$ in both Caſes, will be greater in this Caſe than in the ſecond Caſe, for the reaſon now mention'd, *viz.* becauſe *P A* $= o$ is

a

a common Multiplicator in both, and AHIL in this Caſe, is greater than AHIL in the ſecond.

If $m = 3$ and PA $= \infty$, then as before, AHIL will be equal to nothing, and conſequently the *Attraction* will be $\infty \times 0 = 1$.

If $m = 3$ and PA $= a$, then the *Attraction* will be equal to $\frac{y}{aa} - \frac{3y^2}{2a^3} + \frac{2y^3}{a^4} - \frac{5y^4}{2a^5} + \frac{3y^5}{a^6} - \frac{21y^6}{6a^7}$, &c. After this manner, the Force of the *Attraction* of the *circular Plane* upon the *Corpuſcle* P, may be eaſily computed in any aſſignable caſe of the *Powers* of the Diſtance PF. and at any aſſignable Diſtance of the *Corpuſcle* from the Plane.

From theſe *Calculations* it is evident, that the Force of the *Attraction* of the Plane upon the *Corpuſcle*, when the Diſtance is nothing, or when the Plane and the *Corpuſcle* come into *Contact*, increaſes when the *Powers* of the Diſtance n increaſe;

thus when $n = 2$. and $PA = 0$, the Force of the *Attraction* is greater, than when $n = 1$ and $PA = 0$, and ſo in others higher. As alſo, it's clear from theſe *Calculations*, that the Force of the *Attraction* of the Plane upon the *Corpuſcle*, at the ſame finite Diſtances decreaſes faſter, or at a greater rate, when the *Powers* of the Diſtances are high, than when they are lower, or when n is a greater Number, than when is leſs; thus at the ſame finite Diſtances, the Force of the *Attraction* is much leſs *proportionally*, when $n = 3$, than when $n = 1$, or 2, and ſo in others where the Difference between n in one Caſe and in the other, is yet greater.

Now to apply this to the *Coheſion* of Bodies: It's certain that the firſt Condition (*viz.* when the *Attraction* is reciprocally as the Diſtance between the *attracting* Bodies,) cannot obtain in the *Coheſion* of Bodies; for the Difference between the Force, when the Bodies are in *Contact*, and when they are at ſome Diſtance from one another, in this caſe, is ſo ſmall, as does not anſwer the *Appear-*

ances; for we find, that the Force whereby Bodies *cohere*, is very much greater, when they come to immediate *Contact*, than when they are at ever ſo ſmall a finite Diſtance from one another.

In the ſecond Condition of the *Univerſal Law* of *Gravitation*,(*viz.* when the Force is *reciprocally* as the *Squares* of the Diſtance,) the Difference of the Force of *Coheſion*, between Bodies at immediate *Contact*,and of the ſame, at ſome Diſtance from one another, is greater than in the former Caſe; But not ſufficient to account for this Difference obſervable in the manner of the *Coheſion* of Bodies. But if it were poſſible to gather by *Experiment*, the *proportion* of the decreaſe of this Force, in *cohering* Bodies, to the ſame, at ſome determin'd Diſtances from one another, that would give the Condition of the *Univerſal Law*. But it will be very difficult to make any ſuch *Experiments*, becauſe the Fluids which ſurround Bodies, upon the Surface of our *Globe*, get in between the Surfaces of Bodies when they are at any Diſtance, greater than the *Diameters* of the conſtituent Parti-

les of theſe Fluids, and ſo by their lateral
reſſures, deſtroy the efficacy of the Force
whereby Bodies *cohere*; thus the Particles of
ight, and of *Air*, get in between the Sur-
aces of Bodies, remov'd at almoſt an inſen-
ible Diſtance from one another, and ſeeing
ight and Bodies act mutually upon one a-
nother, and that the Particles of *Air*, endea-
vour to recede from one another, they render
he efficacy of the Force of *Attraction* where-
by Bodies *cohere*, altogether inſenſible at any
Diſtances from one another, greater than are
he *Diameters* of the Particles of theſe Fluids;
nd a Diſtance equal to the *Diameters* of ſuch
ubtil Fluids, is too ſmall to be diſtinguiſh'd
by our Senſes, howſoever aſſiſted. How-
ever this be, it is very evident, that all the
Appearances of the manner of the *Coheſion*
of Bodies, may be explain'd from this *Prin-
iple of Gravitation*, together with that other
already mentioned, of the plainneſs of the
Surfaces of *cohering* Bodies; for if all Bodies
ohere after one and the ſame manner, then
one Condition of this *Univerſal Law* of *Gra-*

vitation will ſerve; if ſome Bodies attract one another after one manner, others afte another (and theſe Diverſities to ſome may ſeem not improbable, to account for th different Degrees of Firmneſs, Solidity an *Coheſion* obſervable in Bodies) then, ther is ſufficient variety in this *Univerſal Law* t account for all theſe Diverſities; ſo that it' evident that from theſe Principles, *Coheſio* in all poſſible Caſes may be explain'd.

§ XLVI. *Coheſion* in general being thu explain'd, it is no hard matter to underſtan *Elaſticity*, which ſeems to ariſe from th ſame *Principles*, of ſmooth and plain Surfaces, and of ſome one or more of the mention'd Conditions of the *General Law of Attraction.* In bending *elaſtick* Bodies, w find the *Convex* ſide exceedingly ſtretch'd in ſo much, that by frequent and long continued Bendings, there become viſible *Fiſſures*, in the out-ſide, which no doubt wer there before, or in the firſt Bendings, tho not ſo large, as to be viſible, as alſo we ſe the *Concave* ſide, mightily contracted, or its Parts forcibly preſs'd together, ſo as to run into Folds or leſſer *Convexities*, on the in-ſide: the ſame thing happens, when two *elaſtick* Globes, or Balls, ſtrike againſt one another, only the *Convex* ſides, are turn'd in towards their *Centers*; the matter being thus, let us ſuppoſe, that two very ſmooth and lain ſquare Surfaces, are join'd together, o that each Particle in theſe Planes, attracts nother, by ſome one or other of the Conlitions of the *General Law of Attraction*, if heſe Planes, by any external Force, were ſo eparated, as to move upon a common ſide f the Congruent ſquares as an *Axis*, and that o forein Fluid endow'd with a disjoining orce (ſuch as *Air* and *Light* are) cou'd inrpoſe, to hinder their Action: it is certin, that the external Force which thus ſearated theſe Planes, ceaſing to act, the *Atactive* Force wou'd immediately bring eſe Planes together again, and if theſe lanes were ſeparated by a *parallel* Motion, the Diſtance were ſo ſmall, that no forein

Fluid could get in to hinder their Action, if the *ſeparating* Force ceas'd, the *attracting* Force would act and bring 'em together again; and in both Caſes, with a Force which may be eaſily gathered from the Condition of the Law of *Attraction*, and the Diſtance of theſe Planes being given. Now all *Elaſtick* Bodies in their Actions upon one another, changing their Figures, muſt of neceſſity have ſome of their Parts in theſe Actions, ſeparated by a *parallel* or a circular Motion about an *Axis*; or by a Motion after ſome manner compounded o both theſe, (for it is no matter after wha manner they are disjoin'd, provided they b not ſeparated, ſo far, as to admit any forei Fluid to enter, which may deſtroy the efficacy of the Force, whereby theſe Particle *attract* one another.) If we then ſuppoſe the Surfaces of the Parts of *Elaſtick* Bodies plain and ſmooth, and that they *attract* on another after ſome one or other Conditio of the *Univerſal Law*; being ſeparated by forein Force, they muſt (when that Force cea ſes) join together again with a certain degree of Force, (which is to be eſtimated from the Diſtance, and Condition of the *Univerſal Law* being given,) and ſo will produce all the *Appearances* of *Elaſtick* Bodies. Upon the ſame *Principles*, may the *Elaſticity* of *Tendinous* Bodies, be explain'd, but it is not my Buſineſs here, to deſcend into all the particular Circumſtances. If *Elaſtick* Bodies obſerv'd one conſtant *Proportion*, in their unbending, toward their bending Forces, it were eaſie from thence, to determin the Condition of the *Univerſal Law* by which their Particles attract one another; but perhaps ſome may think, there are as great Varieties in this as in *Coheſion*, I ſhall not therefore trouble the Reader, in this place with the particular Conſequences, from particular Conditions of the *General Law* of *Attraction*, but ſhall content my ſelf to have laid down the only *Principles* upon which theſe intricate, and hitherto *deſpair'd of Appearances*, may be accounted for.

I would proceed to the reſt of the *Appearances* of Nature which I am ſatisfy'd can be accounted for, from the ſame *Principles*, but that theſe already explain'd are moſt of what I ſhall make uſe of in the following Treatiſe, for which this *Chapter* was deſign'd only as a *Lemma*: Beſides that, ſome of the reſt will naturally come into the Subject of theſe Diſcourſes.

THE *Philoſophical Principles* OF Natural Religion.

CHAP. II.

Of the Origination of this World, and of Mankind in particular.

§ I. IT is a little ſurpriſing to ſee Men ſometimes contending and wrangling about the *Origin* of their ſeveral Families; and yet ſcarce any Body give Himſelf the trouble once ſeriouſly to conſider or enquire how Man at firſt became to *be*, whether he ſprang from the *Earth* or dropt from the *Clouds*, when he began, or if ever there was a time when he was not; tho' theſe Enquiries be far more worthy a wiſe Man's pains than thoſe inſignificant Conteſts. We are eaſily ſatisfy'd we and our own immediate Parents have not been for ever; but few of us go farther, we take this World as we find it, without troubling our Heads *who made it*, or whether it was *made* or not. No Body can well bear to have their *Anceſtors* affronted, nor their *Pedigree* deſpiſed; and yet very many now a days don't ſcruple to own themſelves the *Children* of the *Earth*, or the Offſpring of *blind Fate and Chance.* Whatever others may do, I ſhall not think my Pains ill beſtow'd once in my Life to have examin'd how this preſent ſtate of things became at firſt to *be.*

§ II. There are three general Opinions about this matter, the firſt is of thoſe of the Epicurean Sect, that holds that an *immenſe Void*, and an Infinity of differently figur'd, very ſmall, extreamly hard and infrangible *Particles of Matter* have for *ever been*; and that theſe Particles moving of 'emſelves in a direction oblique to one another, after innumerable *rencounters*, did at laſt ſettle in this *beautiful Order of things* we now behold. This is the *Scheme* upon which ſome build their *Hopes*, and upon the account of which ſome of our *Moderns* think 'emſelves ſubtil *Philoſophers*, how juſtly we ſhall now examine.

§ III. Firſt this *Scheme* ſuppoſes Matter to have for ever been of it ſelf, without any Cauſe; which is a very liberal Compliment to ſuch an unactive inanimate Maſs, to make it independent for its Being and uncapable of being deſtroyed (both which *Self-exiſtence* neceſſarily implies) 'tis to raiſe it to a very high pitch of Dignity, to which we find none of its other qualities anſwerable. *Time* and *Space* it's true may have for ever been; but that is becauſe they may have ſome relation to a Being endow'd with all other ſuitable qualities; but Matter ſeems to be too ignoble a Being to arrogate ſuch high *Endowments*. But paſs we over this Head, as

not

not eſſential to the Buſineſs in Hand. And,

§ IV. Let us conſider how out of theſe few *Principles* of an *immenſe Void*, an infinity of very ſmall, hard, and infrangible *Particles*, and their *oblique Direction* to one another, it is poſſible to form this preſent ſtate of things. We have have prov'd § XI. of the preceding Chapter, that *Motion* is no more *eſſential* to Matter than Reſt, that of it ſelf it can never bring it ſelf into Motion, that it wou'd for ever continue in the ſtate it is put in, and, if it was from all Eternity at reſt, it would continue ſo for ever; if in Motion, it wou'd for ever move on. But I'd gladly know whence this motion did proceed, ſince it is ſuppos'd there is nothing beſide unactive Matter it ſelf to produce it. Whatever can be ſuppos'd to put Matter in Motion, may at the ſame time, and with the ſame eaſe, be ſuppoſed to have directed the ſeveral parts thereof to the Places they are now in, *i, e.* to have produc'd this *preſent ſtate of things*.

No Body can think Motion *eſſential* to Matter, who ſees any part thereof at reſt; for what is *eſſential* to any thing, that thing can never be without it. But ſome *Philoſophers*, and thoſe of great Name too, have aſſerted that no part of Matter ever was nor can be at abſolute reſt. For, ſay they, Motion is a Quantity, and may be divided *in infinitum* as well as other Quantities, and a Body may be moving any finite time, and yet never ſenſibly change its *relative* Place; for the ſpace is as the Velocity, and if the Velocity be very ſmall, the ſpace it moves through is ſo likewiſe: And that thoſe Bodies which ſeem to be at reſt, are only alternately moving very ſlowly to and from the *termination* of the Motion, or the *Obſtacle.* To this I anſwer, that tho' it may be very true, that nothing in this Univerſe is actually at *abſolute reſt*, but that every thing is in ſome degree of Motion; yet that abſolute Reſt in Bodies is not impoſſible, is clear from hence, that it implies no contradiction, a Sphere in a vacuity ſhou'd be preſs'd by two other equal Spheres with equal Forces and contrary Directions; from which preſſure the intermediate Sphere wou'd be at *abſolute Reſt*; wherefore if it is not abſurd a Body ſhou'd be at *abſolute Reſt*, it is impoſſible Motion ſhou'd be *eſſential* to Matter. There is another Argument which to me ſeems very concluſive againſt Motions being *eſſential* to Matter, and that is from the infinite poſſible Varieties of its Directions; laying aſide the conſideration of all other Bodies; or, ſuppoſing a Body moving *in vacuo*, it muſt move in one certain *Direction*. Now what is it that determines it to this *Direction* rather than to any other of the infinite Variety; no Reaſon can poſſibly be aſſign'd why it ſhou'd move rather in this than in any other of the infinite number of Directions. And it cannot poſſibly move in more than one of 'em at once, and therefore it will of itſelf move in none of 'em, *i. e.* it will not of it ſelf move at all, and conſequently Motion is not *eſſential* to Matter. For in the faculties of natural things which are not endow'd with Free-will, where there is an infinite variety of Choice, and no poſſible Reaſon to determine any one way, there can be no Choice made at all. From all which it is plain, that allowing the *Abettors* of this *Philoſophy* their *Void* and their *Atoms*, yet nothing cou'd be produc'd for want of Motion, it not being *eſſential* to Matter, as has been prov'd, and there being nothing elſe to produce it.

§ V. But allowing Matter to be *ſelf-exiſtent* and *ſelf-moving*, I wou'd know whence came this *obliquity* of *Direction*, this is to aſcribe Will and Choice to theſe Particles, and to alledge that they are capable of reſolving what way they will go. The Contrivers of this *Scheme* ſaw wiſely enough, that granting theſe *Atoms* to be *ſelf-moving*, yet nothing wou'd follow but an eternal wandering in Lines *parallel* to one another, without any other effect; and therefore they added, that theſe Particles moved with different *oblique Directions* to one another; by which means they wou'd meet and juſtle and reflect, in innumerable different ways. But does not every Body ſee that it is as eaſie and as intelligible to ſuppoſe this World already in Being, as to ſuppoſe theſe Particles endow'd with this *obliquely* directed Motion, the Cauſe of the one being no leſs accountable from their Principles than the other. We ſee all Motions now perform'd in the ſame direction with that of the moving Force, and all Motions produc'd by the ſame *adequat Cauſe* have the ſame *Directions*; and conſequently, if the Motion of theſe Atoms ariſes from 'emſelves, they muſt all follow the ſame *Directions*, *i. e.* they muſt all move in *parallel* Lines; and conſequently they cou'd never meet in order to produce any regular Effect. We do not find that Matter or Bodies now can alter their Directions, and yet according to the Opinion of theſe Men for infinite Ages by-paſt, they have mov'd as they liſted. Why do they not ſo ſtill? Since (according to their own ſuppoſition) nothing has happen'd to alter their Nature, or the manner of their Motions ever ſince; it is altogether unaccountable why Matter ſhou'd move in one *Direction* rather than another, upon any other account but the *Direction* of the impreſs'd Force, and all that's alleged on this Head by the *Favourers* of this *Scheme* is altogether *precarious.*

§ VI. But allowing theſe *Atoms* to be *ſelf-exiſtent*, *ſelf-moving*, and *obliquely* directed, yet 'tis ſtill inconceivable how they ſhou'd produce a World. For theſe *Atoms* cou'd not move all with the ſame degree of Obliquity to one another, for that wou'd be making 'em all *converge* to a point, and ſo nothing but one great ſolid Sphere cou'd be produc'd; if they happen'd to unite after their Meeting, and if they again reflected from one another, they wou'd produce a fluid Sphere, their rectilinear Motions turning into circular ones, or otherwiſe wander on in right Lines as before: And to make ſome converge to one point, others to another; is to ſay theſe Atoms were intelligent free Beings, which cou'd chuſe the courſe they wou'd go in. We have a very powerful Proof of the inſufficiency of theſe *Atoms*, tho' endow'd with their *obliquity* of *Direction* to produce any thing, in the Rays of the Sun, which as was before prov'd are very ſmall parts of Matter, by the interpoſition of the ſurfaces of reflecting Bodies differently ſituated, obtaining all poſſible varieties of Obliquity; and yet theſe produce no regular *Syſtems* of Bodies, tho' they move and probably juſtle and interfere all imaginable ways. As I have juſt now ſaid, only thoſe whoſe *Directions* converge to a point, cou'd meet to produce any real Body, and ev'n the Body which wou'd be produc'd wou'd only be a *ſpherical* one. So that out of all their Motions, only *Spheres* of different Magnitudes cou'd be form'd, which how ſmall a part this is of the infinite variety of Bodies in this Univerſe, I leave the Reader to conſider. The truth of the matter is, if Bodies were *ſelf-moving*, they cou'd move what way they pleas'd, and ſtop when and where they pleas'd, *i. e.*

they wou'd be free-will'd *Elective* Agents.

§ VII. Again, allowing theſe *Atoms* to be *ſelf-exiſtent*, *ſelf-moving* and *obliquely* directed, yet I wou'd gladly know how from thence this *Univerſe* cou'd be fram'd. It is not enough to ſay barely theſe *Atoms* thus diſpos'd wou'd at laſt ſettle into this ſtate of things, unleſs it be ſhewn by what particular *Motions*, *Directions* and *Reflections*, the principal Bodies of this Univerſe were fram'd. To ſhew a thing poſſible to be done, we muſt tell how, what way, and by what Laws it may be done. For unleſs we deſcend to Particulars, we are never certain it can be ſo; and 'tis as probable (till the contrary be evinc'd, in ſome Particulars at leaſt) it may not be ſo. *Generals* are always to be ſuſpected, a Contradiction may be diſcovered in the particular Explications of an Appearance that was not taken notice of in the *general Scheme*; as indeed it happens in every individual Inſtance of this preſent Subject hitherto attempted. I ſhall not ask of thoſe who defend this *Scheme*, a particular account of the *Mechaniſm* of every individual Appearance in our *Syſteme*, for that indeed were endleſs. But if any one can tell by what Laws of Mechaniſm, any one Animal or Vegetable was produc'd, or from what mechanick Principles the Planets deſcribe *Elliptick* Orbits, I ſhall for the ſake of theſe allow their whole *Scheme* to be true. We all know how wretchedly *Des Cartes* (the ableſt *Patron* that ever this Opinion had) has blunder'd on theſe Heads, and his Followers have not mended the matter much. It is ſurpriſing to think how any reaſonable Man cou'd believe this *Univerſe* to have been produc'd by Matter and Motion; when as yet no Man that ever liv'd, from theſe Principles alone, can tell by what *Mechaniſm* the moſt contemptible of the *Celeſtial* or *Terreſtrial* Bodies cou'd be produc'd; and yet to be fully ſatisfy'd of the truth of this *Hypotheſis*, a Man muſt underſtand the particular Mechaniſm of the whole *Syſtem* of things, and of every individual Appearance.

§ VII. Theſe *Atoms* are ſuppoſed *infrangible*, extreamly compacted and hard (as indeed the leaſt parts of Matter muſt neceſſarily be) which *compactedneſs* and *hardneß* is a demonſtration that nothing cou'd be produc'd by 'em, ſince being ſo they cou'd never come to cohere, in order to produce ſolid Bodies. The only tolerable account of *Coheſion* in ſuch like Particles is from their branch'd Figure. Now hard ſolid Particles reflecting from one another, can never poſſibly lay hold of one another, at leaſt not ſo but that the leaſt Motion will disjoin 'em again. It is impoſſible to conceive how innumerable hard and compacted *Atoms* ſwimming in an immenſe *Abyſs* cou'd ever come to cohere ſo as to produce ſuch hard Bodies as *Diamonds* and ſome other *Mineral Subſtances* are, without any other cement but their catching hold of one another; this mutual embracing might keep 'em from being eaſily torn aſſunder, but they wou'd be ſtill movable like chain'd Work, and cou'd never produce the appearance of

Firmneſs and Solidity. And what is here ſaid of Coheſion and Solidity, may be likewiſe ſhewn of Elaſticity. And thus allowing theſe *Atoms* to be *Self-exiſtent*, *Self-moving*, *obliquely* directed, and to meet according to any Laws of *Mechaniſm*, yet they cou'd only produce looſe heaps of *Atoms*, or ſuch movable ones that are altogether unlike the ſolid Bodies we now behold. So that to account for the production of this preſent ſtate of things, beſides their Matter and Motion, the *Abettors* of this Opinion want a Principle for Solidity or Coheſion and Elaſticity; Both which are owing to no eſſential Property of Matter, as is ſhewn in the two laſt Sections of the preceding Chapter.

§ VIII. There are ſeveral *Appearances* abſolutely unaccountable from the Laws of *Mechaniſm*, and conſequently theſe cou'd never be produc'd by Matter and Motion alone, or any *Combinations* of them. It were endleſs to allege all the Inſtances that might be brought on this Head, ſome few of the moſt conſiderable will ſuffice; for if any one be inconſiſtent with the Laws of *Mechaniſm*, then it is impoſſible this *Syſteme* cou'd have been produc'd by the concourſe of *Atoms*. The firſt I ſhall inſtance in, is that great Law to which all the Bodies of this Univerſe are ſubject, *viz.* That of *Gravitation*. In the former *Chapter* I have endeavour'd to ſhew that this Property is not *eſſential* to Matter, nor can ariſe from the Figure, Texture or Motions of its Parts, but is *implanted* therein by ſome Power ſuperiour to that of Matter; whence it is evident that one of the primary Attributes of Matter is independent of the Laws of *Mechaniſm*. That active Principle which animates as it were the dead Maſs of Bodies, and which is the Cauſe of all the beautiful *Appearances* of Nature, owes its Origin to ſomething different from Matter and Motion, and therefore this *Syſtem* of things cou'd not ariſe from thence.

§ IX. Not only *Gravitation*, or that implanted Principle whereby Bodies tend towards one another, is above the Powers of Matter, but all the Effects and Appearances that neceſſarily depend thereupon, *i. e.* all the *Celeſtial* and *Terreſtrial Appearances* are likewiſe above the Powers and Laws of Matter and Motion. All the Attempts of others before Mr. *Newton*, to explain the regular and conſtant *Appearances* of Nature, were moſt of 'em *Ungeometrical*, and all of 'em ſo inconſiſtent or unintelligible, that it was as hard to allow their *Poſtulata* as to conceive the thing which they pretended to account for from them. All the *Philoſophers* that ever were, cou'd never from the meer Laws of *Mechaniſm* explain how the Planets came to move in *Elliptick* Orbits, they might (if Matter had been ſelf-moving) have for ever ſtray'd in right Lines; but, that they ſhould conſtantly revolve in Orbits, that they ſhould approach to and remove from a determin'd point at different Seaſons, and that uniformly and conſtantly, is altogether unaccountable from the Laws of *Mechaniſm*, as has been ſhewn in the former *Chapter*. But from this implanted Principle of Gravitation, all the *Phænomena* are accounted for, and that to the greateſt nicety we are capable of diſtinguiſhing. So that not only this Univerſe cou'd not have been produc'd by the Laws of *Mechaniſm*, but there is ſcarce a ſingle *Appearance* that can thence adequately be accounted for.

§ X. The Production of Animals is altogether inconſiſtent with the Laws of *Mechaniſm*. 1. The Blood is ſqueez'd by the force of the Heart from the left *Ventricle*, through the Arteries unto the Extremities of the Body, and is thence return'd by the Veins into the right *Ventricle*; thence by the *Arteria Pulmonalis* unto the *Lungs*, from the *Lungs* by the *Vena Pulmonalis* to the right *Ventricle* again. The Motion of the Heart is caus'd by the nervous Juices mixing with the Blood in the *Muſcular* part thereof. And theſe nervous Juices are both deriv'd from the Blood, and forc'd into the *Muſcular* part of the Heart, by the Motion of the Heart itſelf, the Texture of their containing Veſſels, and perhaps by the pulſation of the Arteries upon the Nerves in the Brain. Here now the Heart is the Cauſe of the Motion of the Blood in the Arteries, and the Motion of the Blood in the *Arteries* urging their Juices through the Nerves, is the Cauſe of the Motion of the Heart, which is a plain *Circulation* of *Mechanical* Powers; *i. e.* a *Perpetuum Mobile*, which by what was ſaid in the preceding Chapter is contrary to the Laws of *Mechaniſm.* If an *Epicurean Philoſopher* cou'd contrive a *Water Machin* that the Water ſhou'd move the *Machin*, and the *Machin* the Water; ſo that the ſame Water ſhou'd conſtantly return in a Circle to move the Machin: I ſhou'd then think their *Scheme* ſomewhat feaſible. But, ſince the firſt is demonſtrably impoſſible, the latter muſt be ſo likewiſe. 2. In all Animals there are *Organs* in number actually indefinite if not infinite. By an *Organ* I mean a diſtinct independent part of a *Machin*: Thus a Wheel and all its parts is an *Organ* of a Watch, if I may ſpeak ſo; and a *Gland* with all its parts, or a Canal from its Origin to its Extremity is an *Organ* in an Animal Body. Now theſe Organs or independent parts in the Animal, are infinitely many, which is evident both from the Nature of *Senſation* and *Nutrition*. *Senſation* is perform'd by the mediation of an *Organ* ariſing from the Brain and continued through the part affected. Now there is not the leaſt imaginable ſolid part of the Veſſels or Muſcles but is ſenſible; and therefore the Organs in Animals that convey this Senſation, are infinite in Number. To this perhaps it may be objected, that one *Organ* may convey *Senſation* through ſeveral places, and conſequently tho' ev'ry minute part of the Body be ſenſible, it will not follow that the Organs which convey this *Senſation* are infinitely many, ſince they may all be only the continuation of ſome few *Organs* through different parts. But the Anſwer is obvious, if every point of the Veſſels and Muſcles of the Animal Body be ſenſible, then the *Organs* which convey the Senſation are infinitely ſmall, and if infinitely ſmall they muſt be infinitely many, ſeeing their Extremities in the Brain conſtitute a finite *Superficies*, or fill a finite Space: For a finite number of infinitely ſmall parts can never make a finite Quantity. Again, *Nutrition* is perform'd by an Organ, through which the Supply is convey'd to the Place to be nouriſh'd, and ſince there is no part of the Body that may not be encreas'd or diminiſh'd (as is evident from the Cure of Wounds in all Places through which the neceſſary part of the Fluids of the Body can paſs) it is plain that ev'ry individual point of the Animal Body is the termination of an *Organ* through which the *Nutrition* may be convey'd. Moreover ſeeing even the Canals themſelves do encreaſe in bulk, may decay and be impair'd, ev'ry aſſignable part of theſe Canals muſt be the termination of ſome *ſecretory* Duct ſeparating a fluid fit to encreaſe their Dimenſions or repair their Loſſes; and theſe ſecretory Chanels again muſt have others to encreaſe *their* bulk or repair *their* Loſſes, and ſo on *in infinitum.*

infinitum. Add to all theſe, that the fineſt Glaſſes diſcover nothing in the ſeveral parts of the Veſſels and Muſcles but fine ſlender Canals; and the better the *Microſcopes* are, the greater Number of thoſe capillary Pipes are diſcovered; and theſe parts which were formerly reckon'd *Parenchymatous* are now found to be bundles or heaps of exceedingly ſmall Tubes or Threads. The Muſcles themſelves conſiſt of a Number of Fibres, and each Fibre of an incredible Number of little *Fibrils*, bound together and divided into little Cells or *Veſicles*, the Glands are nothing but a *clew* of little ſlender Pipes diverſly rolled or folded together; the *Brain* is a numberleſs *Congeries* of infinitely ſmall Tubes woven into ſeveral Figures; the *Nerves* are bundles of ſmall *cylindrical* Pipes; and the *Lungs* and *Liver* are but Heaps of little Bladders upon which the Blood Veſſels are ſpread in Net-work; or of little Glands among which theſe Veſſels are diſperſed. In one Word, all the ſolid parts of the Body are nothing, but either very fine exceeding ſmall Tubes for the conveyance of ſome fluid, or ſlender Threads, in Bundles ty'd together by others ſurrounding 'em, or going from one Fibre to another, or ſpread out into thin Membranes: For the *Bones* are nothing but ſuch Bundles, and all the Membranes or Membranous Coats of the Veſſels, are nothing but theſe Threads wrought together into thin Skins. From all which it is beyond diſpute, that every Animal is made of Organs in Number really infinite. For theſe Organs become at laſt infinitely ſmall, and ſo their Sum muſt be infinitely many, ſeing it conſtitutes a finite Quantity. Now how ridiculous is it to imagine a thing ſo wonderfully made cou'd be the Effect of meer Chance, or of the blind Laws of Motion. In *Artificial Machines*, the more complicated and compounded the Contrivance of the Parts is, the greater the difficulty is in adjuſting them; and the difficulty encreaſes in the ſame proportion the *complications* do, and conſequently when the *complications* are infinite the

Machin is altogether above the Power of *Mechanicks*, and quite impracticable by the Laws of Matter and Motion: But this is exactly the preſent Caſe, and therefore the Production of an Animal is altogether *immechanical*. 3. Allowing Animals might have been produc'd by the caſual concourſe of *Atoms*, why do not theſe very ſame Cauſes continually operate, and why do we not ſee the ſame Effects in our Days (ſince the Cauſes continue the ſame) that were beheld in former Times? If any of the *Philoſophers* ſhou'd ſhew us ſuch an Appearance; nay, if they wou'd but tell us (without runing upon Contradictions) how ſuch a *Machin* might be produc'd, we might begin to hearken to their Pretences. But ſince ſuch a thing was never ſeen nor pretended, it's very arrogant in them to think People ſhou'd believe the Matter without any Reaſon upon their meer Word. No Body now-a-days that underſtands any thing of Nature or *Philoſophy* can ſo much as imagine that any Animal how abject ſoever can be produc'd by an *equivocal Generation*

neration, or without the conjunction of Male and Female Parents, in the ſame or in two different Individuals. And very few who have conſidered the Matter but own that ev'ry Animal proceeds from a preexiſtent *Animalcul*, and that the Parents conduce nothing but a convenient Habitation and ſuitable Nouriſhments to it, till it be fit to be truſted with the Light, and capable of receiving the Benefit of the Air. We know very well that there is nothing in the *Animal Machin*, but an infinity of branching and winding Canals, fill'd with Liquors of different Natures, going the ſame perpetual round which are no more capable of producing the wonderful Fabrick of another Animal, than a thing is of making itſelf. Beſides, in the *Generation* of an Animal, there is a neceſſity that the *Head*, *Heart*, *Nerves*, *Veins* and *Arteries* ſhou'd be form'd at the ſame time, which can never be done by the Motion of any fluid what way ſoever mov'd; for as hath been juſt now ſaid, the Heart cannot move, unleſs Animal Spirits be ſent from the Head through the Nerves into it; the Animal Spirits cannot be deriv'd into the Heart unleſs the Blood be ſqueez'd by the Heart through the Arteries into the Brain. So that it is evident that the Head and Heart, the Arteries Veins and Nerves muſt be all form'd at the ſame time, if the Animal is *Mechanically* produc'd. But this is altogether impoſſible, for no Motion of any fluid or fluids howſoever diſpoſed can form all theſe at the ſame inſtant. And we know all the internal *Mechanical* Actions of Animals are perform'd by the force of their fluids. Let any one conſider the *Infinity* of Canals and other Organical parts in an Animal, and again conſider that all that one Animal can conduce toward the *Generation* of another is by the force of ſome Liquors through ſome Canals, and try if from this Power he be able to form the Idea of the *Generation* of an Animal. It is doing Penance to read the wretched Accounts of the wiſeſt and moſt learned *Philoſophers* on this Head. To obſerve how in every ſtep they contradict the known Laws of Motion; and indeed the manner after which they wou'd have 'em generated is as much above the Power and beyond the Laws of *Mechaniſm* as the true and genuin Manner and Method of their Production is. From all theſe Conſiderations, it is evident that an Animal cannot be produc'd mechanically, it is too hard a Probleme to be ſolv'd from ſo few *data* as Matter and Motion. For indeed cou'd this one be once ſolv'd by any of the *Philoſophers* we ſhou'd be eaſily ſatisfy'd of the reſt, tho' Plants and all the vegetable Kingdom be liable to the ſame Difficulties, and furniſh us with the ſame Objections; for they are indeed only Animals of a lower Rank. And cou'd it be once prov'd either by *Demonſtration* or by *Matter* of *Fact* that a Plant or an Animal cou'd be produc'd by *Mechaniſm*, *i. e.* Nature, or the Laws of Motion, the thoughtful parts of Mankind wou'd be eaſily tempted to believe, that ſince the better part was produc'd by Mechaniſm, the meaner *i. e.* all the reſt of this viſible World might have been form'd the ſame way. So that it is a Matter of the greateſt Conſequence that we have demonſtrated, that neither Animals nor Vegetables can be produc'd *Mechanically*. There are many other Arguments which I can produce to prove the ſame Propoſition which the Language I write in will not permit me to ſet forth.

§ XI. The *Spontaneous* Motions of the ſenſitive part of this *Syſteme* is an eternal contradiction to the Laws of *Mechaniſm*. We have ſufficiently ſhewn that neither *Spontaneous* (nor indeed any) Motion is eſſential to Matter, it is determin'd to one direction (while in Motion) which it can no more alter than move of itſelf. This our Senſes may daily inform us of, the Ball goes on in the direction of the Club or of the Body of the Piece out of which it is ſhot, the Arrow in that given it by the Bowſtring, and the Hand of the Dial-plate in that given it by the Wheels, and that neceſſarily and conſtantly if not forc'd out of the ſame by ſome foreign Violence. But all *Senſitive* Animals have a *Self-moti-*

on, can turn and wind, move through all the points of the Compaſs; go back and forward as their Occaſions require, or Inclinations prompt 'em. It's true, ſome of our Modern *Philoſophers* have aſſerted, that the *Brute-Creation* are only pieces of Clock-work, and that all their Motions are as neceſſarily determin'd as that of the Dial-plate. But this is meerly precarious, and may be deny'd as eaſily as it is confidently alleg'd. Beſides the Demonſtrations *à priori* I have juſt now brought to evince the contrary, the Obſervation and Experience of all Mankind contradicts it. The *Docility* and *Segacity* of ſome Animals demonſtrate the contrary, and ſome *Brute-Animals* ſhew more Indications of it than ſome of the Race of Mankind on whom they beſtow it. What more evident Proofs of a *ſpontaneous* Motion cou'd theſe poor Creatures give than they do, if they were really ſuppos'd to be endow'd with it? Nothing but a ſenſation in our ſelves of the *Principle* of their Actions cou'd create clearer Evidences of a *ſpontaneous* Motion.

Beſides, it is altogether impoſſible to account for the far greater part of their Actions and Motions from *Mechaniſm*, as we have in the preceding Propoſitions ſhewn at large. And we ſhou'd be ſtrangely ſurpriz'd if by any combination of material Organs, we ſhou'd produce the ſmalleſt part of their Actions and Paſſions. Wherefore ſince the ſenſitive World is endow'd with *ſpontaneous* Motions, and ſince this is far beyond and above the Powers of Matter, it is evident this Univerſe cou'd not have been produc'd *Mechanically*.

§ XII. The *Voluntary Motions* of Rational Creatures are altogether unaccountable from the Laws of *Mechaniſm*. Muſcular Motion is perform'd much after ſuch a manner as this; the Muſcles are Bundles of Fibres, which being cloſely compacted at both ends make their two *Tendons*, each of which is inſerted into ſome one fixt part of the Body or other, every one of theſe Fibres conſiſts of a prodigious Number of leſſer Fibres or *Fibrils* which are ſo many very ſlender elaſtick Canals bound about by ſmall tranſwerſe parallell Threads which divide theſe hollow *Fibrils* into ſo many elaſtick *Cyſtes* or *Veſiculæ*, as if a Gut were ty'd at equal diſtances. Into every one of theſe *Veſiculæ*, an Artery, Vein, and Nerve enter, the two firſt to bring and carry back the Blood, the latter to carry thither likewiſe its proper fluid; which mixing in the *Veſiculæ* with the Blood, produces a rarefaction (the manner how, for avoiding Diſputes, I ſhall forbear at preſent to determine) whereby theſe *Veſiculæ* are diſtended, and their *Longitudinal Diameters* (from Knot to Knot) ſtraitned, and ſo the length of the whole Muſcle ſhortned. The Nerves are the *ſecretory* Ducts of the *Glandulous* Subſtance of the Brain, and conſequently are much of the ſame Nature, with the other *Excretories* of the Body, which are nothing but ſmall ſlender ſlips of the Arteries for deriving an appropriated Juice from the Blood. Wherefore ſince the nervous Juice is form'd out of the Blood, and ſince the Nerves are very ſmall Arterial Tubes, this

Juice muſt move in theſe Nerves after the ſame manner the Blood does in the Arteries; only with this difference, that it moves abundantly more ſlow, (its Velocity being abated either by the many circumvolutions of the Artery in the *Gland*, which is the Origin of the Nerve, or by the reſiſtence the Juice meets with in the ſlender Pipe of the Nerve it ſelf.) If the *circulation* of the Blood be admitted, and all the Juices of the Body be allow'd to be deriv'd from it, 'tis impoſſible that any of theſe Juices ſhou'd ſtagnat in their Veſſels longer than till they be fill'd. And therefore the nervous Juice in its Channels is propell'd after the ſame manner and by the ſame Mechaniſm the Blood is urg'd forward in the Arteries. Now in the Muſcles of involuntary Motion, ſuch as the Heart, the Lungs, the Stomach and Guts, and the muſcular Coats of the Veſſels, this nervous Juice is conſtantly deriv'd by a *Mechanical* Neceſſity. In the Heart, while the *Auricles* are full of Blood, they are diſtended, and the influence of the nervous Juices into their Muſcles thereby ſtop'd; but when once this Blood begins to flow into the *Ventricles*, the reſiſtence ariſing from the diſtenſion of the *Auricles* to the influx of the nervous Juice is taken off, and ſo it flows into the muſcular Subſtance of the *Auricles* and thereby they are contracted, while the *Ventricles* are diſtended, and the influx of the nervous Juice into their Muſcles is thereby ſtop'd, till the Blood be deriv'd into the *Aorta*, and the Impediment from this diſtenſion to the influx of the nervous Juice be taken off, and ſo the *Ventricles* come into Contraction; which hinders the Blood from running any more into the *Ventricles* from the *Auricles*, and then the *Auricles* are again fill'd: And thus, by a *Mechanical* Neceſſity they act *alternately*, the Auricles and Ventricles being as it were *Antagoniſts* to one another; ſo as that while theſe are diſtended thoſe are contracted, the diſtenſion of the firſt permitting the influence of the nervous Juice into the latter; and ſo on the other hand. After the ſame manner are the *muſcular*

cular Coats of the Blood Veſſels, and of the Coats of the other Veſſels containing Liquors deriv'd from the Blood, *alternately* contracted and dilated; for by the contraction of the Heart the Blood is thrown into the Arteries, which diſtends them, and ſo the influence of the nervous Juice into their Muſcular Coat is hindred; but when the Blood is by the *impetus* it has conceiv'd deriv'd into the Veins, this impediment is taken off, and the Muſcular Coats of the Arteries then act, the *Membranous* by their *Elaſticity* concurring. In the Lungs the Gravity of the *Atmoſphere* forces the Air into the ſmall orbicular Veſicles thereof, and dilates the Cavity of the Breaſt; whereby the preſſure of its Sides upon them, and the Nerves that act in this function is taken off, and ſo the Muſcles of the *diafragm* and the other concurring ones are at freedom to act, and to diſtend the Cavity of the *thorax*, till the preſſure of the ſides of the Breaſt become too ſtrong for theſe oppoſite combin'd dilating Cauſes; and then by their own Gravity and the elaſtick force of the Ribs they fall down and compreſs the Lungs and ſhut np the Emiſſaries of the Nerves. So likewiſe in the Stomach and Guts, when the *Longitudinal Muſcular* Fibres are in Action, the *Tranſverſe* and *Spiral* ones are relax'd by the preſſure of the acting Fibres upon the Emiſſaries of the Nerves of the relax'd ones; and ſo on the other Hand, when thoſe are relax'd theſe are in action, and univerſally in all the *involuntary* Motions there is a *Mechanical* Neceſſity for the derivation of the nervous Juices into the Muſcles employed in theſe Motions. But in voluntary Motions there neither is nor can be any ſuch Mechanical Neceſſity, it being a plain Contradiction to their Nature; and therefore voluntary Motion is quite contrary to the Laws of *Mechaniſm:* we can move our Hands and Feet how and when we pleaſe in an Inſtant, we can bend and unbend' em as we will. There is no *Mechanical* Cauſe imaginable to force this nervous Juice into the Muſcles of voluntary

Motion, and no Motion can follow unleſs this Juice be deriv'd, as is plain from hence, that cuting the Nerves that ſerve any Muſcle, tho' all other things continue the ſame, yet no Motion will follow. And the only Conception we can form of voluntary Motions, is that the Mind like a skilful *Muſician* ſtrikes upon that Nerve which conveys animal Spirits to the Muſcle to be contracted, and adds a greater force than the natural to the nervous Juice, whereby it opens its Paſſage into the Veſicles of which the Muſcular Fibres conſiſt, which it cou'd not have done by its natural Power. But this Action of the Mind or Will upon theſe Animal Spirits being altogether unaccountable from the Laws of Motion, it is plain that voluntary Motion is altogether *immechanical.* And indeed were it *Mechanical*, it cou'd not be Voluntary; for what ever acts *Mechanically*, acts conſtantly and neceſſarily, and ſo can never act voluntarily.

§ XIII. That *Freedom* and *Liberty* of chooſing or refuſing which we find in our ſelves is altogether inconſiſtent with *Mechaniſm*. Some Men indeed deny that we have any Free-will at all; but theſe need only examine their own Conſciences to be convinc'd of their miſtake; they will find that even when their Reaſon wou'd determine 'em to do ſuch a thing, they have in their Power to forbear it or to do the contrary; they can riſe or ſit ſtill, go backward or forward, to ſhew their own *Freedom*; they can chooſe the time and Place the Degrees and Circumſtances of all theſe Actions that are call'd free. It's true ſome of our natural Actions are neceſſary, but theſe which are commonly call'd voluntary Actions, are as much free as the nature of things will permit them. Their Power being limited, I wou'd gladly know what greater *Indications* of freedom they cou'd wiſh to have, than they now have. The Paſſions of Mankind (which in moſt, determine their Actions) are indeed violent, but they have it in their Power to ſuſpend for ſome time the ſatisfying of them; which ſhews they are not neceſſarily determin'd toward their Satisfaction; for the Action of neceſſary Agents can only be ſuſpended by a Miracle. Let us ſuppoſe that Man in a perfect ſtate of Health, is free and has a Power of *election*; the only *Indications* he cou'd give of this Freedom, are by doing the contrary, where there are weighty and ſolid Reaſons for doing ſuch a thing; or by making an *Election* among many things, when there is no imaginable Reaſon to determine him more to one than another; or to be able to ſuſpend the effect of natural Actions, when without this interpoſition they wou'd *Mechanically* operate. Now it's certain that we are capable of giving all theſe *Indications*, to ſhew our Freedom: we have it in our Power to hurt or even deſtroy our ſelves tho' there be the beſt Reaſons in the World to hinder us from ſo doing, we can take out the one and not the other, in two or more of the ſame things in all Circumſtances alike:

Tho' *Reſpiration* be reckon'd an involuntary Action, and tho' it is certainly perform'd *mechanically* and uniformly, yet we have it in our Power to keep in our Breaths and to ſuſpend the efficacy of this natural *Function* for ſome time; and this ſeems to be one of the moſt evident *Indications* of Freedom that can poſſibly be deſired. For tho' in other Caſes it may be alledg'd that it is the ſubtil and *imperceptible* manner after which we are determin'd that makes any of our Actions ſeem free, yet in this Inſtance that Objection can have no Place; for if we are determin'd ever ſo *imperceptibly*, it is by the Neceſſity of Nature we are determin'd. Now it is abſurd to think that Nature ſhou'd determine any natural *Function* to be perform'd regularly and conſtantly the ſame way, and that by *Mechanical* Laws, and at the ſame time determine this *Function* to be irregularly and uncertainly ſuſpended. On the other Hand, if we are neceſſarily determin'd in all our Actions, and if we have no Freedom, it is abſolutely impoſſible we ſhou'd make any Election among things in all Circumſtances alike; for if we are determin'd, it can only be from the things themſelves without us, for all things within us are upon this *Hypotheſis* to be ſuppos'd to move uniformly and *Mechanically*. Now where the things without us are in all Circumſtances alike, we can never be determin'd to any one of them by themſelves. And therefore were we not free, we cou'd never make an Election among things altogether alike. By things altogether alike, I mean ſuch as are alike as to all the Circumſtances neceſſary to conſtitute them the things requir'd. Thus two Farthings are altogether alike, tho' they may differ in ſome ſmall Circumſtances that do not concern the *Eſſence* of that *Species* of Coin. Thus 1. 3. 5. 7. 9. are equally odd Numbers, and 2. 4. 6. 8. equally even Numbers, and if it were propos'd to aſſign an even or odd Number, there are infinitely many which are equally ſuch. The ſame thing happens in the Anſwers to all theſe

Problems which are call'd *indetermin'd*; and in aſſigning one of the Anſwers to any ſuch *Problems*, there is nothing in their Nature that can poſſibly determine us, the Conditions of the Problem only being had reſpect to. And therefore ſuch things as theſe are only pitch'd upon by the energy of our Wills or Freedom. But no Arguments will make a Man confeſs he feels, if he be obſtinately reſolv'd not to confeſs it. Now Liberty is a thing felt, and is only to be found by a *reflexion* on our ſelves and our Actions; but there is one Argument which will always have weight with the wiſer and better part of Mankind. And that is that without Free-will, Virtue and Vice, Juſtice and Injuſtice are only bare Words. Now if Rational Creatures be free, as moſt certainly they are, this Freedom is a plain downright Contradiction to *Mechaniſm*, for *Mechaniſm* produces all its Effects neceſſarily.

§ XIV. Having I think ſufficiently ſhewn the Inconſiſtency and Impoſſibility of the *Epicurean Scheme.* I come to the ſecond Opinion about the *Origination* of the Univerſe, which in few Words tells us very poſitively, that this preſent ſtate of things has been from all *Eternity* of itſelf, ſo as we now behold it; and that any Changes that have happen'd therein, have proceeded from the Laws of *Mechaniſm* that now obtain in the World. This *Scheme* conſiſts principally of theſe two Parts. 1. That this World has been for *ever* in the ſtate we now behold it. 2. That it has been ſo for *ever* of itſelf, independent of any other Cauſe. This Opinion is commonly, but falſly aſcrib'd to *Ariſtotle*, not as its firſt *Broacher* but as its ableſt *Patron.* But tho' *Ariſtotle* held the firſt part of it, *viz.* That the World was from all *Eternity* as we now behold it, yet he did not think it was ſo *of it ſelf*; and there is a very great Difference betwixt allowing this preſent *Syſtem* of the *Univerſe* to have been created from all *Eternity* by an *Omnipotent Cauſe*, and believing it to have been for *ever* of itſelf without any *Cauſe*. My Deſign in the following Diſcourſe is not to diſpute againſt any *Scheme* of thoſe who admit the Exiſtence of a *Deity*, I intend only to ſhew, that this preſent ſtate of things cou'd not have been from all *Eternity*, neither of it ſelf, nor without the frequent and particular interpoſition of a *Divine Power*; and to make it plain that naturally and of itſelf it tends to *Diſſolution*; Tho' in the mean time, it is not to be doubted but that that *Almighty Power* which cou'd create this *beautiful Syſtem* of things, can preſerve it in being as long as He pleaſes.

§ XV. That this Univerſe cou'd never have been ftom all *Eternity* of itſelf, in the preſent condition it now is, is evident from hence, that it requires an *extrinſick Principle* for its ſubſiſting in its preſent Condition. If one ſhou'd ſee a Piece of *Clock-work*, pointing out the Diviſions of time exactly and regularly, he might have ſome Difficulties about the manner of its Production; but if he ſhou'd ſee or learn that it requir'd ſome *Foreign Aſſiſtance* to keep it a going, that its Motion depended upon ſome Principle without itſelf, that it requir'd winding up of the Spring or Weights, he wou'd be ſoon ſatisfy'd it cou'd not have been from all Eternity of itſelf in the ſtate he then beheld it. Now this is the very Condition of the *Earth*, the *Moon* and *Planets*, and of all the *Celeſtial* and *Terreſtrial* Appearances. Their Motions and Actions depend upon a Principle quite *extrinſick* to Matter, which ariſes from none of its Powers or Properties, as has been ſhown in the former Chapter. The Power which produces and preſerves their Motions, ſprings from ſomething without themſelves, and if this Power were ſuſpended or withdrawn, they wou'd immediately ſtop and their Motions wou'd be deſtroy'd, and they wou'd become a lifeleſs unactive heap of Matter. And this Power is nothing elſe but that univerſal Law of Gravitation, which *actuates* the whole frame of all the *Syſtems* of Bodies; which proceeds from a Principle both independent of, and diſtinct from Matter and all its Faculties.

culties. Wherefore it is altogether impoſſible this preſent ſtate of things ſhou'd have been from all Eternity *of itſelf*, ſince at preſent it cannot ſubſiſt in a regular and beautiful *Syſtem* without the perpetual influence of ſome ſuperiour and *extrinſick* Power.

§ XVI. Whatever depends upon another thing as its *Cauſe*, as alſo, whatever is neceſſarily requir'd for the Exiſtence or Preſervation of another thing, theſe cou'd not have been from all Eternity *of themſelves*; for *Self-exiſtence* neceſſarily implies independency as to Exiſtence on any other thing, either as Cauſe or as Effect; (I mean only of thoſe things which are about us, *viz.* The viſible things of this World, which have but Qualities both finite in Number and Degree; and conſequently have *aſſignable* relations to and dependences upon one another; for it is otherwiſe in the *Immenſe Being* in reſpect of his Creatures, which can have no Proportion to him, and he no dependence on them.) And when a thing depends upon another thing as its Cauſe, this implies that the firſt thing exiſts that the ſecond *may exiſt*; which ſuppoſes Deſign and Contrivance, and conſequently is a ſign of Production or Creation, and not of the Self-exiſtence of theſe things. Likewiſe, when a thing is neceſſarily requir'd for the Exiſtence or Preſervation of another, it plainly implies that the firſt thing exiſts that the ſecond *may exiſt*, which likewiſe ſuppoſes *Deſign* and *Contrivance*, and conſequently can be no ſign of *Self-exiſtence* in theſe things. Now is there any thing more plain, than that moſt of the things in this our *Syſtem* are neceſſary or uſeful towards the Being or Preſervation of *Mankind*. Remove the *Sun* from us, or us from the *Sun*, the Earth cou'd bring forth no Fruits for our Support; take away the *Moon*, the *Seas* wou'd ſtagnat and the Fiſh be deſtroy'd; level our *Mountains* we ſhou'd have no freſh Waters; deſtroy our *Atmoſphere* or the Airs Elaſticity, we ſhou'd ſwell like poyſoned Rats. Do not theſe and a thouſand other Inſtances I cou'd allege, demonſtrate that all the Beings of this Univerſe exiſt as the neceſſary Effect, or for the Exiſtence or Preſervation of other Beings, and conſequently imply *Contrivance* and *Deſign*; which is a moſt evident ſign that all theſe things have been produc'd and are not Self-exiſtent. If a wild *Scythian* or *Indian* who never ſaw a Houſe in his Life, ſhou'd meet with a *Noble Palace* neatly finiſh'd and finely furniſh'd, and about it ſhou'd find Creatures that cou'd not ſubſiſt without ſuch a Convenience, and ſhou'd plainly diſcover, that the Accommodations and Conveniencies of this *Building* were exactly ſuited in every Circumſtance to the Wants and Neceſſities of theſe Creatures; I think he wou'd have no difficulty in concluding that this Houſe was built by ſome wiſe *Architect* for the Convenience of theſe Creatures, he wou'd certainly never dream that it had for ever been there of itſelf ſo as he then beheld it. Now this is the very Caſe betwixt us and the *Syſtem* of things about us; not that I think the whole *Syſteme* of the Univerſe was made for us of the *Race of Mankind*, but that we cannot be without a great many of theſe things that are round us, and that conſequently we were ſome part in the deſign of them, and ſo they cou'd not have been for ever of 'emſelves.

§ XVII. That *Animals* cou'd not have been from all Eternity is plain, for both the Reaſons alleged in the two former Sections. For 1. Their Production and Exiſtence depend upon Principles quite extrinſick from and independent of themſelves, I mean of their *Material part*. I have formerly ſhown, that they can neither ſubſiſt nor be produc'd by the Powers of *Mechaniſm*; but for both require the conſtant influence of a Principle even different from that which governs the inanimated part of the Univerſe, *viz. Gravitation*. Now all that is obſervable in this World, (according to this *Scheme*) is Matter and Motion (for if we once allow a Power diſtinct from theſe, we ruin this *Hypotheſis*; for we do not then know how far the influence of this Power may reach, as to the Production and Preſervation of the preſent ſtate of things.) But the Production and Preſervation of *Animals* is above the Powers of Matter as has been formerly ſhown, and therefore ſince they depend upon a Principle diſtinct from and independent of the Laws of *Mechaniſm*, and need a continual influence of ſome Principle, diſtinct from Matter and its Properties, they cou'd not have been for ever of themſelves. 2. All the ſeveral Parts and Organs of the Animal Body are ſo prudently adapted to the benefit of the whole *Compoſitum* as plainly implies Deſign and Contrivance, that it is impoſſible to conſider this, and imagine they have been Self-exiſtent. How wiſely are the *Bones articulated?* How prudently the *Muſcles* contriv'd? and how conveniently faſtned to the ſeveral Places of the Body to produce the neceſſary Motions? With what Judgment are the *Arteries*, *Veins* and *Nerves* rang'd? With what Wiſdom are their fluids diſpos'd in their proper

Veſſels? How carefully is the propagation of the *Species* provided for according to ſeveral Circumſtances ariſing from the particular Climate and Element each *Animal* is confin'd to, and how juſtly is every Particular adapted for the Benefit of the whole compound? I ſhall have occaſion to purſue theſe Inſtances farther hereafter, but any Body who is ever ſo little acquainted with the *ſtructure* of an *Animal*, cannot but diſcover evident Footſteps of *Deſign and Contrivance* in it, and therefore Animals cannot be Self-exiſtent.

§ XVIII. It has been formerly ſhewn in § XXX. and its Corollary of the preceding Chapter, that ſome part of the nouriſhment of *Animals* and *Vegetables*, and the greateſt part requir'd to the production of *Minerals* and *Metals* is a watery Fluid, impregnated with ſome other Body, which by theſe Operations upon Matter is chang'd into a ſolid Form, of which but a very ſmall part is ever reſolv'd into Water again, whereby the quantity of Water on this our Globe is daily impair'd and diminiſh'd; wherefore if the World had laſted from all Eternity in the State it now is, we had long ſince wanted both ſalt and freſh Water. And indeed this decreaſe of the Quantity of Water on our Globe is ſo conſiderable, that a *very great Man* is of Opinion that the *Comets* were deſign'd to ſupply the ſame, which when they come nigh our Dwelling, ſend us ſuch a Quantity of Vapours from their *prodigious* Tails, as is ſufficient to ſupply the Expenſes of Water till the Return of another *Comet*. But we ſo ſeldom receive Viſits from theſe *Celeſtial* Bodies, and we are ſo little ſenſible of the difference of the Quantity of Water falling then and at other times; and theſe *Comets* are when they come within our Regions at ſo great a diſtance from us, that no ſuch conſiderable Effects as may anſwer our Demands are, I fear, to be expected from 'em. Beſides, the Wiſdom of Nature generally ſupplies regular *Deficiencies* by regular and uniform

Cauſes, and tho' the decreaſe of fluidity on this our Globe may not be ev'ry Year of the ſame Quantity exactly, yet it ſeems to be more conſtant and regular than the returns of theſe *Comets*; but of this we ſhall have Occaſion to diſcourſe at more length in the following Chapter. Wherefore, ſince it's certain that the Quantity of Water on our Globe does daily decreaſe (tho' perhaps not ſenſibly) had the World *Eternally been*, the whole Face of this Earth had been more parch'd than the Deſarts of *Arabia*; which not being ſo, it is plain this preſent State of things has not been from all Eternity.

§ XIX. It has been prov'd likewiſe in the preceding Chapter, that the *Light* of the *Sun* does daily decreaſe, and that the Body of the Sun does continually grow cooler; the ſame may be ſaid of the *fixt Stars*: Now had the *Sun* and *fixt Stars* been from all Eternity, we ſhou'd have been reduc'd long before this time to a State of utter Darkneſs. We are very certain that the Rays of the Sun are impriſoned in our Plants and *Vegetables*, in our *Metals* and *Minerals*, and are retain'd by the Action of Bodies upon Light; and ſome part of them by their ſeparation from others, and their being impriſon'd in theſe Subſtances, and the Action of Bodies upon Light, are for ever hinder'd from returning to the Body of the *Sun*. We are certain likewiſe that the Fountain of our Heat daily impairs, that the vaſt Body of the *Sun* is perpetually a-cooling, and tho' theſe Effects be not ſo conſiderable as to become ſenſible in three or four thouſand Years (tho' if ancient Hiſtories be true, this abatement and diminution of the Light and Heat has not been inſenſible) yet in an infinity of Ages (this diminution being ſtill ſomewhat) the Sun had been redu'd to the Heat and Light of a Candle long 'ere this time; and we had been involv'd in a more than *Cimmerian* darkneſs. But ſince we obſerve no ſuch Effect as this, it is plain the World has not laſted from all Eternity.

§ XX. But that which does infallibly demonſtrate that this preſent ſtate of things, both had a beginning and that of themſelves they muſt have an end, is, that our *Earth*, the *Planets*, the *Sun* and *fixt Stars* do not move in Spaces altogether void. But in ſuch that do make at leaſt ſome reſiſtance to their Motions; I have ſhewn in the preceding Chapter, that the Reaſon why, for example, the *Planets* move about the *Sun* is that the Body of the *Sun* attracts theſe *Planets*, and likewiſe theſe *Planets* attract the *Sun*, and that (ſince the *Planets* deſcribe *Elliptick* Orbits about the *Sun*) the attractive Force of the Sun upon the Planets is *reciprocally*, as the *Squares* of the different diſtances of the *Elliptick* Orbit from the *Suns* Center in its *focus*. But that beſides, theſe *Planets* were driven at firſt, or at the beginning of their Motion (to ſpeak ſo) by a Force whoſe direction made an Angle with the attractive Force; or that at the very ſame time the attractiive Force of the Sun exerted itſelf on theſe *Planets*, they were puſh'd along in right Lines by a Force whoſe direction was in ſome manner or other inclin'd to that of the direction of the attractive Force of the Sun, otherwiſe they cou'd never have revolv'd in Orbits. So that it's evident the Motion of the *Planets* about the Sun, is compounded of two different Motions in two different Directions, either of which being deſtroy'd the Planets muſt have fall'n into the *Sun*, or ſtray'd for ever in right Lines; and tho' the reſiſtence of the *Medium* cannot alter the *Centripetal* Motion, (ſo I call that whereby the Planet tends towards the Sun) yet if there be any reſiſtence in the *Medium* through which the Planets paſs, the *projectil* Motion, (ſo I call the other) muſt decreaſe and (in an infinity of Ages) be deſtroyed. Now tho' Mr. *Newton* has conſidered the reſiſtence ariſing from the *Expanſion* of the *Elaſtick Atmoſpheres* of the *Planets*, and cannot ſay it is abſolutely nothing, (for he only finds that it's not ſufficient to deſtroy the *projectil* Motion in a very a very ſhort time,) yet he has not mentioned that ariſing from the fluid of *Light* which reaches beyond the Orbit of *Saturn*, and tho' we have ſhewn in the preceding Chapter, that this fluid is extreamly thin and its parts eaſily moveable, yet ſtill they make a fluid; and this fluid muſt give ſome reſiſtence to Bodies paſſing through it, which tho' very ſmall, muſt in an infinity of Ages have been ſufficient to have quite deſtroyed this *projectil* Motion. If the Light of the Sun be a Body (as we have prov'd it to be) it muſt reſiſt other Bodies that move in it, and if it be but the *Action* of lucid Bodies communicated by the impulſe of one Body upon another, in a ſtrait Line, without the *actual* Motion of any one of 'em, yet ſtill it is neceſſary that there be a *Series* of Bodies interpos'd betwixt the lucid Body and the illuminated Object, which will as much reſiſt the paſſage of Bodies, as if the parts of Light mov'd themſelves; ſo that in both Caſes there muſt be ſome reſiſtence made to Bodies paſſing through this Ocean of Light;

which tho' not ſenſible in any finite time, muſt have been ſufficient in an infinity of Ages to have deſtroy'd the *projectil* Motion, and conſequently long e're now all the *Planets* had been broiling in the Sun, had the World laſted from all Eternity; which not having happened, it's plain this preſent ſtate of things has not laſted from all Eternity in the Order we now behold it.

§ XXI. Since it has been ſufficiently demonſtrated in the preceding Chapter, that Motion is not eſſential to Matter, that no particle thereof nor any *Combinations* of particles can bring themſelves to Motion, and ſince there are various and different Motions obſervable in this preſent ſtate of things, it's evident that the Matter or Bodies of this Univerſe has been ſome time or other before this preſent time put in Motion, but more eſpecially ſince no Body put in or ev'n endow'd with Motion, can of itſelf revolve in an Orbit or any *curve* Line, *per Coroll.* 3. of the firſt *Law of Nature*; and ſince we ſee the *Celeſtial* Bodies do move in *curve* Lines it's plain they have not for ever mov'd of themſelves, and conſequently they have not for ever exiſted in the ſtate we behold 'em. It is altogether impoſſible for any Body to move in an Orbit or any *curve* Line of itſelf, becauſe at every different point it muſt change its direction; and to ſuppoſe a Body capable of changing its direction at every different point of its Courſe, is to ſuppoſe it to have Reaſon and Diſcretion. And ſince to move in an Orbit or any *curve* Line is to move with a Motion compounded of two other Motions, one of which at leaſt muſt have been impreſs'd, ſince it cannot move of itſelf by both, by the *Corollary* now mentioned. Therefore before the one of theſe Motions was impreſs'd, it was in a different ſtate from what it was in, after that other Motion was impreſs'd. So that ſince the *Planets* do revolve in Orbits or *curve* Lines, it is plain they have not for ever been in the ſtate we now behold 'em of themſelves.

§ XXII. If the *fixt Stars* be not actually infinite in their Number, then this preſent ſtate of things muſt of neceſſity both have had a beginning and muſt have an end. It's certain theſe luminous Bodies do mutually *attract* each other, ſince it's abſurd to imagine Matter not to be of the ſame uniform Nature every where; and it's as certain they do not revolve about any common Center or Centers, ſince they have been obſerv'd never to have varied their ſituations or diſtances from each other. Now if they be finite in Number, the terminating Bodies of the material part of the World muſt be all free from Attractions towards the void part, and ſo muſt be all approaching toward the *common Center of Gravity* of the whole; and had the Frame of the World been eternal, they had long e're now all of 'em met there. *Space* indeed may be infinite in its extent, but there is no imaginable Reaſon to believe the Number of the *fixt Stars* is infinite, nor the material part of the Univerſe boundleſs, ſince we have very good Reaſon to believe that the ſolid Subſtance has a very ſmall Proportion to the Vacuities interſperſed even in our *Syſtem*, and the Matter of this Univerſe is almoſt nothing in reſpect of the containing Space, as has been inſinuated in the former Chapter. For ſince Space is infinite (as I ſhall hereafter demonſtrate) and ſince there's a neceſſity of admitting of actual Vacuities as I have formerly ſhewn; it's plain, Matter cannot be infinite in its extent, ſince thereby it is not equal to *Space.* Now if the fixt Stars be finite in their Number, or the material part of this Univerſe limited in its extent, the Bodies at the limits of the material part being quite free from attractions upon the ſide toward the infinite Space, muſt yield to the attracting Force of the Bodies toward the *common Center of Gravity* of the material part, and the *Boundaries* yielding, the Bodies next them muſt do ſo likewiſe, and ſo on ev'n to the Center; for nothing but an equal attraction on all Hands can keep the *fixt Stars* conſtant in their Places, and nothing but an infinite Number rang'd up and down the infinite Space can be ſufficient for this; wherefore ſince it has been evidently demonſtrated that the material part of this Univerſe is finite in its extent. If the World had laſted from all Eternity the whole Matter of this Univerſe had been long before this time amaſs'd in the *common Center of Gravity*, and had there made a lifeleſs Heap; which not having happened it's plain this World has not laſted from all Eternity, nor can of itſelf continue to all Eternity. And it's not unlikely that the vaſt if not immenſe diſtances of the *fixt Stars* from us and one another, has been deſign'd to retard this Effect as long as the deſigns of Providence may require.

§ XXIII. In the former part of this *Chapter* I have demonſtrated the impoſſibility of the *Mechanical* production of *Animals* and *Vegetables*, and I ſhall have Occaſion in the following *Chapter* to make it evident, that ev'ry generated *Animal* is produc'd from a preexiſtent *Animalcul* of the ſame *Species*, and that ev'ry *Vegetable* ariſes from a ſmall Plant of the ſame kind. And it is impoſſible it can be otherwiſe upon our Adverſary's *Scheme* of admitting nothing but Matter and Motion, for if *Animals* and *Vegetables* cannot be produc'd from theſe, (and I have clearly prov'd they cannot) they muſt of neceſſity have been from all Eternity. And conſequently that all the *Animals* and *Vegetables* that have exiſted or ſhall exiſt, have actually been all included in the firſt of ev'ry *Species*; or which is the ſame thing, that pitching upon any one *individual* of either kind now exiſtent, that all the *Animals* or *Vegetables* that proceed from it were included in it, and it, with all theſe was included in that one from which it proceeded, and ſo on infinitely backwards; and conſequently ſince there is no new production, all that are or ever have been of that *Species* were once actually together included in one infinitely remote from this now pitch'd upon. And that at any finitely or infinitely diſtant time (if they have ſo long exiſted) from their Generation or Production, all the *Animals* included in the firſt of ev'ry *Species* were there moving and living *Animalculs*, and all *Vegetables* included in the firſt of ev'ry Kind, were there actually growing and encreaſing ſmall Plants. Now ſince every *Animal* and *Vegetable* has been prov'd to conſiſt of *Organs* in Number infinite (tho' if the Organs of *Animals* be only finite in Number, it will as effectually ſerve our preſent purpoſe.) It is abſolutely impoſſible any of the *Species* of *Animals* or *Vegetables* ſhou'd have exiſted from all Eternity; for then their Number muſt have been infinitely many, and the *Animalculs* and ſmall Plants, being *Organical* Bodies and conſiſting of parts, and thoſe infinitely many too, and being all included in the firſt of every *Species*, or thoſe infinitely diſtant from the preſent *Individuals*; theſe firſt ones of ev'ry *Species* muſt of neceſſity have been infinitely big, for infinitely many *Organical* Bodies how ſmall ſoever, amaſs'd together in one Body, dy, muſt make that Body infinitely big; ſo that unleſs we cou'd admit the firſt of ev'ry *Species* of *Animals* and *Vegetables* to be infinitely big (and how abſurd ſuch an *Hypotheſis* is, I leave the Reader to judge) It is abſolutely impoſſible, that *Animals* and *Vegetables* ſhou'd have been from all Eternity; neither can I ſee how this Argument can be evaded, if we admit all *Animals* and *Vegetables* to proceed from preexiſtent ſmall *Individuals* of the ſame Species, included in the firſt of each kind. And it is impoſſible this can be otherwiſe upon our Adverſaries Scheme, if the *Mechanical* Production of theſe be impoſſible, which I think I have clearly demonſtrated.

§ XXIX. Had the World laſted from *all Eternity* as it now is, it is altogether impoſſible but that *Arts* and *Sciences* muſt have been brought to a far greater Perfection than they have as yet attain'd. Let us take for Inſtance the *Mathematicks*, it is certain this Science has been more improv'd within theſe two hundred Years, than in all the time paſt before that, ſince we have any Records; and two or three hundred Years more, going on at the rate of thoſe laſt paſt, may carry 'em to a height which we now cannot imagine. Now it is altogether impoſſible the Improvements already made ſhou'd be loſt, ſeeing they contain things ſo abſolutely neceſſary to the *Accommodation* of Mankind; they will as ſoon forget the uſe of Houſes and Cloaths, as the Advantages to be reap'd from this *Science*; wherefore had the World Eternally been, this Science had been brought to its utmoſt Perfection long e'er now. It may be alleged that *Inundations*, *Deluges*, *Wars* and *Peſtilencies* might have deſtroyed all the former Emprovements, and then we ſhou'd have been left to begin anew. As for *Deluges*, it is impoſſible they ſhou'd have been Univerſal, *i. e.* Naturally and Mechanically impoſſible; for the only *Philoſophical* Account of an *Univerſal Deluge* hitherto aſſign'd, *viz.* that of Mr. *Whiſton*'s, depends entirely upon the Principles of Gravitation, which have been proved not to be *Mechanical*; and ſince there cou'd be no *Univerſal Deluge* naturally, (and to allow a Principle above Nature or the eſtabliſhed Laws of *Mechaniſm*, is to yield the Cauſe) particular Inundations, cou'd never have been ſufficient to have obliterated the remains of Sciences, particularly of this one, which by Inſcriptions on *Medals*, by the Ruins of *Architecture*, by *Pillars*, *Inſtruments*, and *Machins*, might have been preſerv'd in deſpite of every thing but an Univerſal Conflagration. Beſides, it's meerly precarious, to ſay there have been Deluges that have done any conſiderable Damage, to the whole rational Creation, and may be deny'd with the ſame Reaſon it is affirm'd, ſince it is certain we have heard of none of any conſiderable Conſequence. It's true there happen'd an *Univerſal Deluge* in *Noah*'s Days; but beſides, as I formerly ſaid, that this was not brought about naturally, we know not, if this and other Sciences, had arriv'd at any great Perfection before this Deluge happen'd. So that we are not certain if the Perfection of *Arts* and *Sciences* has been much retarded upon this account. Wars and Peſtilences, it's true, have been and may be, but thoſe do not happen univerſally over the whole World at the ſame time; and there are always ſome Countries and many particular Perſons who eſcape; ſo that is impoſſible theſe things cou'd have obliterated all the Remains of *Arts* and *Sciences*. I believe it almoſt impoſſible by any means, except *Annihilation*, or a general Conflagration, ſo to deface the Memory and Remains of all our modern Improvements, that ſome of 'em ſhou'd not laſt at leaſt ten thouſand Years to come; and yet it's certain we have no evident Footſteps of Improvements older than three or four thouſand Years. In ſhort, this Argument holds good againſt ev'ry thing but *Univerſal Deluges*; and to admit or ſuppoſe any ſuch to have been, is to yield the Cauſe, ſince it's impoſſible to explain ſuch by the Laws of *Mechaniſm*, or to account for them by Matter and Motion as things are now ſettled; and to quit theſe, or to allow any thing to have happen'd contrary to them, is to admit *Powers* ſuperiour to 'em, which for ought we know might have produc'd that which they can now ſo powerfully alter. And tho' *Arts* and *Sciences* may have been at a ſtand for many Ages in ſome Countries, yet that is nothing to the whole Globe. For ſince that Principle which prompts ſome Men to improve *Arts* or *Sciences* they are inclin'd to, ſprings naturally in their Minds, according to the *Scheme* of our Adverſaries, and is neither imprinted upon them, nor were the things themſelves reveal'd to them, by any ſuperiour Beings; this Principle in an infinity of Ages, without any *Univerſal Deluge*, or ev'n any particular one of any great extent, muſt have of Neceſſity brought Arts and Sciences, and the other Accommodations of Life, to a much greater Perfection than we ſee they have now attain'd. From all which duly weigh'd, it's plain this World has not Eternally been as it is now. And indeed, the Accounts of our Emprovements anſwer very well to the time, aſſign'd by *Moſes* for the Creation of the World.

§ XXV. If the Number of any *generated* thing, which we behold on this Globe, does either encreaſe or diminiſh continually, in any finite Number of Years how great ſoever, by any finite Number how ſmall ſoever, then this World cou'd not have been from all Eternity in the preſent ſtate we now behold it. For had it encreas'd in any finite Number of Years how great ſoever, by any Number how ſmall ſoever, long before this time their Number had been infinite; ſo that this poor *Mole-Hill* of a *Globe* had not been able to contain 'em: And had they decreas'd, their Number had been none at all, *i. e.* the whole Race had been extinguiſhed. But ſince neither of theſe has happened, it's plain the preſent ſtate of things has not been for ever. It's not eaſie to believe, for inſtance, that the Race of Mankind, has been *ebbing* and *flowing* without conſiderable encreaſes or diminutions, from all Eternity. We are certain *Wars*, *Peſtilences* and *Diſeaſes*, and the other means of Deſtruction, have not been fewer for theſe 300 Years by-paſt; than ever they have been ſince we have Records, and yet it's plain the Number of Mankind has conſiderably encreaſed in that time. Sir *William Petty* from Obſervations on Births and Burials has diſcovered that in 360 Years the Maſs of Mankind is doubled in theſe Countries. Had they thus encreas'd from all Eternity in other Countries, all the *Planets* within our *Syſtem* had not been able to have contain'd them by this time; yea if in many *millions* of Years they had but encreas'd by an Unity continually, their Number had been infinite by this time. But it's plain both the Number of Mankind, and that of other *Animals* and *Vegetables*, muſt have perpetually encreas'd, if the World has been from all Eternity as it is at preſent. And ſince their Number is but finite at preſent, it's evident this World has not been for ever as now it is. And indeed the preſent Number of Animals does anſwer very well to the common *Æra* of the Creation. Theſe two laſt Arguments I have ſubjoin'd, not as concluſive proofs of the Production of this preſent Univerſe in time, but as concurring Confirmations of the former Demonſtrations.

§ XXVI. Laſtly, How improbable is it that this World ſhou'd have been from all Eternity? Is there any thing we ſee in any part of it, or ev'n in the whole, that has any other Quality ſuitable to that *Cardinal* one of Self-exiſtence? We our ſelves are certainly the nobleſt part of this *Syſtem* we are acquainted with; and yet God knows how unfit any of us, or even our whole Race is, to have ſo extravagant a Compliment beſtow'd upon us as Self-exiſtence; when as we can ſcarce be ſaid to be at all, ſo very a nothing our Lives are in reſpect of *Infinite Duration.* We might with as much Reaſon imagine Mankind *Omniſcient* or *Omnipotent*, (which we know too well he is not) as *ſelf-exiſtent*. Theſe qualities cannot be ſeparated;

where one is, all the reſt muſt neceſſarily be. For whoſoever is *ſelf-exiſtent*, muſt neceſſarily and independently be. *Neceſſarily*, becauſe depending only on himſelf alone for Being, he may be when and while he pleaſes; independently, becauſe his Being and all that's neceſſary to it depend on himſelf alone. And whatever neceſſarily and independently exiſts, muſt Be in Opposition of all other Powers, and whoever is ſo, muſt be able to preſerve his Being in deſpite of all other Powers, *i. e.* muſt be *Omnipotent*. Whoever is *Omnipotent* muſt know all things that are poſſible to be done or let alone; for he can never be ſupos'd to do that which he knows not how to do, *i. e.* muſt be *Omniſcient*; and whoever is *Omnipotent* and *Omniſcient*, all things elſe muſt depend on him; for being ſo, he may make all things depend of him if already they did not ſo. Beſides, other things muſt depend of him for the very ſame Reaſon, *viz.* becauſe he can make 'em do ſo. As alſo, whatever is *Omnipotent* and *Omniſcient*, depending on nothing, and having all things depending on him, muſt be ſupremely good and wiſe; becauſe he knows all things, can do all things, has no Reaſon nor Cauſe to determine him to any thing that's bad, ſince nothing can hurt him, nor any Power annoy him. So that it's very plain, that whatever is *ſelf-exiſtent* muſt poſſeſs all the other ſuitable Qualifications. And ſince we muſt of neceſſity admit ſomething to be ſelf-exiſtent, how much more reaſonable is it, to believe that, that *immenſe Being*, which poſſeſſes all other Qualities ſuitable to that of *Self-Exiſtence*, has been from all Eternity; and when it was his Pleaſure, has created this noble Repreſentation of himſelf, *viz.* This beautiful State of things, which bears ſo viſible *Characters* of his infinite Power and Wiſdom, as ſhall abundantly be ſhewn hereafter. And this is the *third Opinion* about the *Origination* of the Univerſe, which muſt of neceſſity be true, ſince after the other two, which I have (I think) abundantly confuted, this is the only poſſible remaining Choice.

THE
Philoſophical Principles
OF
Natural Religion.

CHAP. III.

Of the Exiſtence of a Deity.

§ I. THAT there are no *Speculative Atheiſts*, to me ſeems as evident, as, that no Body who has conſidered the matter, can be abſolutely convinc'd, that the three *Angles* of a *Triangle* are not equal to two *right ones.* The *Fool* indeed may have ſaid in his Heart there is no God, *i. e.* lewd and vicious Men, may have heartily wiſh'd within themſelves, that there were no ſecret Obſerver, nor that there might be any publick *Puniſhment* of their Crimes, becauſe it's their Intereſt there ſhould be neither; but that a Man of an ordinary Underſtanding, who has ſeriouſly ſet about the matter, and has duly weigh'd the Evidences for the *Being of a Deity*, ſhould at laſt come to a full Perſuaſion of his *None-Exiſtence*, to me ſeems as impoſſible, as it is for one who has attentively read the *firſt Book of Euclid*, and rightly uuderſtood what he has read, to be convinc'd that the Sum of the *Angles* of a *right lin'd Triangle*, can be more or leſs than two *right Angles*. It is true moſt Men think nothing of the matter; and few give themſelves the Trouble to inquire whether there be a God or not; they think ſuch idle *Speculations* become thoſe only, who know not to live, and to make the beſt uſe of Life that may be. And of this kind of *Atheiſts* there is abundance in the World; for it's certain we can never determine any thing about what we never, or but very *ſlightly* think of; and there are millions who live and dye ignorant of many Self-evident Truths, becauſe they never took the Pains to conſider them. But the being or not being of a Deity, is a Matter of that Moment to the Government of the World, the neceſſary Conſequences thereof, do ſo nearly concern the Happineſs or Miſery of every *individual rational Creature*; and the Objects that inculcate the Conſideration of it, are ſo many, ſo different, and ſo *conſpicuous*, that none but the wilfully blind, can withſtand ſuch convincing Teſtimonies. Now tho' the the *Demonſtration* of this *great Truth*, *viz.* that there is a *ſupreme Being*, who made and governs this preſent *Syſtem* of things, has employ'd the Care of many *wiſe* and *good* Men, ſo that none can doubt of it for want of ſufficient Proofs, who will but give themſelves leave to conſider; yet ſince the *Evidences* for it, can never be too many, and ſince ſome are to be wrought upon by one ſort of Argument, others by another, I ſhall here ſet down thoſe, which agreed beſt with my manner of thinking, which are founded on the *Principles* of a juſter *Philoſophy*, and a more genuine Explication of Nature, than was known till of late. And I have choſen this way of reaſoning, the rather becauſe our modern *Atheiſts* have taken *Sanctuary* within the Bounds of *Natural Philoſophy*.

§ II. All the Arguments of the *preceding Chapter*, are ſo many Proofs of the Exiſtence of a *ſurpreme Power*, who made and governs this preſent *Syſtem of things*. For ſince this World, cou'd neither be produc'd by the caſual *Concourſe* of *Atoms*, neither cou'd have been from all *Eternity* of it ſelf, as it has been ſufficiently prov'd; and ſince that it now is, no Body doubts, of Neceſſity therefore, it muſt have been produc'd or created, ſome time or another, by ſome preexiſting Power. Now ſince there is nothing elſe in being but *this World*, unleſs we admit that *ſupreme Power* we are now ſpeaking of; and ſince it cou'd neither have been produc'd from the *fortuitous Concourſe of Atoms*, nor have been from all *Eternity* of *it ſelf*; it muſt of neceſſity have been produc'd by that *ſupreme Power*, whoſe Being we now inquire into. Since then this *ſupreme Power*, of neceſſity, muſt have created this beautiful *Syſtem* of things, and ſince exiſting independently, He muſt for ever be, and have been; therefore that *great Power*, muſt neceſſarily now exiſt. All the Difficulty any rational Creature can have about the Exiſtence of a *Deity*, is how to conceive his having for ever been of himſelf without a Beginning. Now if we could avoid this Difficulty, by ſaying that this *Syſtem* was produc'd, by the caſual meeting of *Atoms*, or by alledging it to have for ever been of it ſelf, we might have ſome ſlight Pretence for our *Infidelity*. But ſince this Difficulty, does equally lye againſt all theſe three Suppoſitions, (for if the World has been produc'd by the *caſual Concourſe of Atoms*, then *a Void*, *Atoms*, and *Motion* have for ever been, without a Beginning, of 'emſelves; if it has been from all Eternity *of itſelf*, as it is, then the Caſe is plain, that we muſt allow ſomething to have been without a beginning *of it ſelf.*) Wherefore I ſay, ſince the very ſame Difficulty equally and unavoidably, urges all the three Suppoſitions; is it not more reaſonable and *congruous*, to allow that Being to have been for ever of it ſelf, without a beginning, to whom we may aſcribe, and who does neceſſarily poſſeſs all other ſuitable Perfections; rather than either of thoſe others, which we know are neither endow'd with, nor capable of, ſuch eminent and tranſcendent Qualitys? I will not ſay with *Des Cartes*, that becauſe in our Conception of a Being *infinitely perfect*, there muſt be included *neceſſary* Exiſtence, that therefore ſuch a Being muſt of neceſſity *actually* exiſt. But ſure I am; ſince our main Difficulty in the Conception of the Exiſtence of a being *abſolutely perfect*, is his neceſſary Exiſtence, or his having for ever been of himſelf without a beginning; it is much more reaſonable to ſuppoſe that Being to have for ever been of himſelf, who neceſſarily poſſeſſes all other ſuitable Qualities, than thoſe who neither poſſeſs, nor are capable of any of them.

§ III. The *Exiſtence* of *Matter*, is a plain *Demonſtration* of the *Exiſtence of a Deity*. I believe no body doubts, that there now exiſts a Quantity of *ſolid Maſs*, out of which the *celeſtial and terreſtrial* Bodies were form'd; and tho' perhaps in our moſt ſolid Bodies, there be more Pores than Parts, or more *Vacuity* than *Solidity*, yet there is ſtill ſufficient, not to permit us to doubt of the Exiſtence of Matter. Wherefore ſince Matter now actually is, I wou'd gladly learn how it firſt exiſted. It cou'd never have been of it ſelf, ſince we are certain, that it is deſtitute of all *active* Qualities whatſoever; it cannot move of *itſelf*, nor when put in motion can it reſt of *itſelf*, nor of *itſelf* change it's Courſe, nor alter it's Direction; it can neither change it's *Figure*, nor *Colour*, nor *Situation*; in a word, it is endu'd with no Property but Inactivity, which is but a Negation. How abſurd is it then, to imagine it cou'd have brought *itſelf* into Being, when it can do juſt nothing *of itſelf?* We may as reaſonably imagine that *Nonentity*, ſhou'd bring itſelf to become a poſitive Being, as conceive it poſſible that Matter ſhou'd of *itſelf* for ever have been. Beſides, admitting Matter to have been for ever of itſelf, yet this will not ſolve half the Difficulties, ariſing in the Formation and Production of the preſent State of things, as has been ſhewn in the *preceding Chapter*, and ſhall be now farther illuſtrated. Whereas the admitting of an *infinitely Powerful and perfect Being* to have for *ever* been, and to have created the *ſolid Maſs*, and out of it, fram'd this wonderful *Syſtem* of Things, contracts all the Difficulties of Nature into this one of his *Exiſtence*. For as to the Difficulties of Creation, they vaniſh quite, before *infinite* Power, for Power implies a Capacity to act, and *infinite* Power a Capacity to act every thing not involving a Contradiction. Wherefore ſince Matter now actually is, and yet it neither cou'd have been for ever of itſelf, nor had it for ever been, wou'd that remove the Difficulties ariſing in the Formation of this preſent *Syſtem* of things, but on the contrary wou'd multiplie 'em. Is it not much more reaſonable then, to admit an infinitely wiſe Being to have for ever been *of himſelf?* whereby all the Difficulties, in the conceiving the Manner of the Production of this *Univerſe*, do vaniſh at once.

§ IV. It has been formerly ſhewn, that this *Univerſe* was not form'd by the ſame Laws it now is govern'd, and which it's ſeveral Parts in their Actions do now obey; and therefore of neceſſity there muſt have been ſome Power ſuperior to, and diſtinct from, that of Matter, which form'd this *Syſtem* at firſt, and preſcrib'd Laws for it's Parts afterwards to obſerve. We ſee all the Changes that now happen in this material World, are according to the Laws eſtabliſhed in the *firſt Chapter*. But this *Syſtem* of Things cou'd never have been brought into it's preſent Order, by the now eſtabliſhed Laws of Nature, (ev'n admitting Matter to have been *eternally exiſtent of itſelf*) as I have abundantly ſhewn in the *firſt Chapter*; neither one, nor all of theſe Laws were ſufficient to have ſeparated, that thin and rare fluid of *Light*, from the other groſſer and more denſe ones, and amaſs'd it in the *Sun* and *fixt Stars*; neither did the Laws of ſpecifick Gravities obtain in the *Formation* and *Situation* of the inner Parts of our *Earth*, and the other *Planets*; nor in the *Separation* and *Situation* of the ſeveral Fluids thereof. By none of the known Laws of Motion, was the *Number*, *Magnitudes*, or Diſtances of the *fixt Stars* determin'd, the Figure, Number, Denſities, Gravitations upon one another, Situations and Order of the *Planets* adjuſted, the Number, Diſtances, and Magnitudes of the *Satellits of Jupiter*, the Form and bulk of the *Annulus* of *Saturn* limited. In a word, the whole proceſs of the *Formation* of the *celeſtial* and *terreſtrial* World, as to their principal

Parts and Arrangements, was brought about by none of the Laws of Motion and *Mechaniſm*, that now obtain in this ſettled ſtate of things; or at moſt theſe Laws had but a ſmall Share in their Production. Wherefore ſince this beautiful ſtate of things has not been for ever *of itſelf*, nor cou'd be form'd by the Powers and Laws of Nature, it is plain it has been produc'd by ſomething ſuperiour to Matter and it's Qualities, and conſequently by that *ſupreme* Being, into whoſe *Exiſtence* we are now inquiring. And truly from what has been here ſaid, and a great deal more of the ſame Nature alleg'd in the *firſt Chapter*, it is evident, we can have no Notion of the *Formation* of this preſent State of things, other than what we have of a *Planetary Clock*, or any other complicated *Machin*, form'd by the Hand of a skilful *Artiſt*; where tho' the Rules of Motion, and Laws of Nature, may obtain, yet they are directed, and even ſometimes contradicted, by the voluntary Motions, and the deſign'd Interpoſings of *free Agents*. And tho' this no doubt, be but a very faint Reſemblance of that *noble* and glorious Work, yet it is the beſt and moſt adequate our *Imaginations*, without runing upon evident Contradictions, can frame.

§ V. As the Formation and Diſpoſition of the *great Bodies* of this Univerſe, did neceſſarily require the Hand of a Being infinitely powerful; ſo likewiſe did their firſt Movement, and impreſs'd Motions, demand the Impulſe of an almighty Hand, to ſet them firſt a going. For ſuppoſing the *celeſtial* Bodies already form'd, and rang'd according to their ſeveral Diſtances from one another; yet without this Impulſe, they had continu'd unactive, unmoving, Heaps of Matter. Now it has been already ſhewn that no Particle of Matter, nor any *Combination* of Particles, can move themſelves and therefore it was abſolutely neceſſary that ſomething different from themſelves, ſhou'd put them in a motion, with a due Velocity along the *Tangents* of their ſeveral *Orbits*;

otherwiſe they had for ever continued in the places, and at the Diſtances, they were at firſt ſet. Wherefore ſince it is certain that theſe *glorious Bodies* have been rowling about theſe four or five thouſand Years; and ſince it hath been demonſtrated that they are not ſelf-moving, being *ſolid Maſſes of Matter*; ſince it has likewiſe been ſhewn, that they have not mov'd from all Eternity *of themſelves*, it is plain, that they have been ſet a going by ſome powerful Hand; and what Hand ſufficient for ſuch a Work, but his who is infinite, both in Strength and Skill; and conſequently he who did ſo *great and glorious* things muſt neceſſarily *be*.

§ VI. Not only the *Formation*, and firſt *impulſe* of the great Bodies of this Univerſe, along the *Tangents* of their *Orbits*, but their *Centripetal* impulſes, whereby their Revolutions or *orbicular* Motions are perform'd, did, and ſtill do, require a Power beyond that of Matter, and the Laws of Nature, to the preſervation of

their

their Motion. Mr. *Newton*, and after him Dr. *Gregory*, has demonſtrated, that to the Motion of any of the *Celeſtial* Bodies in an *Orbit*, there is neceſſarily requir'd two Impulſes, one along the *Tangent* of the *Orbit*, another toward the Center, about which the Body moves. The firſt ~~being~~ once impreſs'd, does continually perſevere, and needs no more to be renew'd, as is evident from the firſt Law of Nature: The ſecond continually draws the *celeſtial* Body from it's *rectilinear* Motion, and forces it into a *curvilinear* Orbit, ſo that it muſt be repeated ev'ry Minute of time. Now theſe *ſecondary* Impulſes ariſe from that *Univerſal Principle of Attraction*, whereby every Particle of Matter, and all the Bodies of this Univerſe tend toward one another; and by which the *Sun* being the far greateſt Body of this our *Syſtem* draws toward him the *Planets*, and they their own *Satellits*; and without which they wou'd for ever wander in right Lines. But it has been demonſtrated in *the firſt Chapter*, that this Principle whereby the *Revolu-*

Revolutions of theſe glorious Bodies are perform'd, is independent of the Laws of *Mechaniſm*, and only accidental (noways *eſſential*) to Matter, but implanted therein by ſome extrinſick Power, and conſequently (ſince it muſt be repeated every Minute) muſt be perpetuated in it by ſome uninterrupted Influence. And ſeeing there is nothing in Nature, but Matter and the Powers thereof, unleſs we admit that ſupreme Being for whoſe Exiſtence we contend, therefore the Revolutions of the *celeſtial* Bodies in their ſeveral *Orbits* do neceſſarily infer the Exiſtence of a Deity.

§ VII. The *Exiſtence* of *Animals* does neceſſarily infer the *Exiſtence of a Deity*; for it has been demonſtrated in the *former Chapter*, that all Animals are in their own Natures *perpetua mobilia*, that they have ſome Principle above the Powers of Matter that governs their Motions; it has likewiſe been ſhewn, that every *individual Plant* and *Animal* is a *Machine* of an infinite Number of Organs; that no Animal is or can be produc'd, or generated by the Force of Matter, and Laws of *Mechaniſm*, (that all *Animals* and *Vegetables* that ever were or ſhall be, were all created or formed at once, ſhall be afterwards ſhewn) and that all theſe are abſolutely unaccountable from the Laws of Motion, and conſequently, muſt ſpring from a principle independent of, and altogether above the Powers and Properties of Matter. Now when ever we forſake the Powers of Matter, and the Laws of *Mechaniſm*, we neceſſarily muſt have Recourſe, to the *Exiſtence* of ſome Power ſuperiour to, and independent of Matter, and all it's Laws and Properties; and conſequently to that *infinitely Perfect Being*, into whoſe Exiſtence we are now inquiring, ſince there is nothing beſides Matter and its Properties in the World, unleſs we admit the Exiſtence of that *ſupreme Being*.

§ VIII. The *ſpontaneous* Motions of *irrational*, and the voluntary Motions of *rational* Animals, the *Freedom of Will*, and Liberty of chooſing or refuſing in the latter, and in a word all the *Appearances* of Nature, which are above the Powers of *Mechaniſm* (which are innumerable) are ſo many undeniable Proofs of the *Being* of a *God*. For ſince this preſent *Syſtem* of Things, has not been from all Eternity *of itſelf*, and ſince theſe are allow'd to be above the Powers of *Mechaniſm*, they muſt have been produc'd by ſome Power Superiour to thoſe of *Mechaniſm*. But no Power is ſufficient for thoſe, but his *who alone does great and marvellous things*, who adjuſted all the Parts of this noble *fabrick* by weight and meaſure, and therefore he that brought about all theſe glorious things, *who alone does Wonders*, muſt neceſſarily *be*.

§ IX. The Preſervation of the *Being* and Faculties, both of the animate and inanimate Part of this *Syſtem* of things, does neceſſarily require the Power, and conſequently the *Exiſtence* of a Being abſolutely perfect, *i. e.* of a Deity. For ſince this *Syſtem* of things has not been from all Eternity of itſelf, as we now behold it, and ſince there is no neceſſary Connexion between the being of any one Part thereof, or of it's Faculties, this preſent Moment, and their being the next, and ſince we ſee both have been preſerv'd for a conſiderable time: This preſervation of the *Being* and Faculties of things, can never be accounted for, without having Recourſe to an *Almighty* Power, which may be ſufficient for all things not involving a Contradiction; and therefore that *Omnipotent* Being indow'd with this Power, muſt neceſſarily *be*. Let us take, for inſtance, the Preſervation, of a Body moving, in it's Motion: Ev'ry *motive* Force (as all other Quantity) may be ſuppos'd divided into ſeveral Parts (the Sum of all which muſt be equal to the *motive* Force firſt propos'd.) This motive Force being impreſs'd on a giv'n Body, muſt produce a Motion therein equal to the Motion produced by all the ſeveral Parts thereof, impreſs'd, either at once, or at different times. Now the Motion produc'd by any one Part of this Motive Force, may be deſtroy'd (by the Oppoſition of an equal Body, impell'd with a Force equal to that Part of the Motive Force we wou'd deſtroy, but with a contrary Direction) the reſt of the Motion remaining unaltered; therefore the ſeveral Parts of any impreſs'd Motion have no *neceſſary* Dependence upon one another, ſince one can be deſtroyed without the reſt; and conſequently the Perſeveration of a Body in Motion, does not depend upon the Nature of Body, nor upon the Nature of Motion, but upon ſome Principle *extrinſick* to both, *viz.* that firſt Law of Nature (preſcrib'd by the Author thereof) whereby Bodies as much as in them is, perſevere in that ſtate of Motion or reſt they are put in, unleſs forced to change the ſame by ſome *foreign* impreſs'd Violence. Moreover, Motion may be conſidered, as the *Tranſlation* of a Body from one place into another. Now there is no imaginable connexion between a Bodies being in this place now, and in another hereafter; and therefore the Perſeveration of a Body in motion, is not all *eſſential* to it. Laſtly, ſince an impreſs'd Force is not at all permanent in the Body mov'd, but conſiſts in the meer *Action*, and it's Efficacy is ſpent that very Moment it is impreſs'd; it is evident therefore, that the Perſeveration of a Body in motion, is neither owing to the motive Force, nor to the Body mov'd. But to that *vis inerciæ*, which is implanted therein by ſomething diſtinct from Matter and its eſſential Properties, *i. e.* to *God Almighty*, the Author of Nature and all its Productions. After the ſame manner in the deſcent of heavy Bodies the *Acceleration* of their Motion may be reſembled (or is *equivalent*) to the *Acceleration* of a Body impelled by a conſtant equable Force, acting ev'ry Minute equally, and by that means adding a new Velocity to the former. Now, any one, or any Number of theſe Impulſes may be deſtroyed without the reſt; and therefore the ſeveral Impulſes, by which heavy Bodies deſcend, do not depend upon one another, ſince by contrary ry equal Impulſes they may be deſtroyed, and conſequently the Degrees of the *Acceleration* of the Motion of heavy Bodies deſcending, have no neceſſary Connexion one upon another, and ſo the Preſervation of this Faculty of Attraction in Matter which is the Cauſe thereof does not depend upon Matter, and therefore muſt be aſcribed to a higher Power. And the ſame may be ſaid of the Being of, (and of all the Faculties not eſſential to) Bodies; for the Being of any thing now, does by no Means infer it's being the next Minute, unleſs the thing be *ſelf-exiſtent* (which cannot be true of Matter, nor of any of it's Faculties, as has been formerly ſhewn) or unleſs Time or Place cou'd change the Natures of things, which is abſur'd. And univerſally, whatever is not eſſential to a thing, that thing can be without; whatever any thing can be without, the Continuation of that is not owing to it, (I mean of inanimate things) *i. e.* to it's Nature, and conſequently requires ſome Power above it, for the Cauſe of it's Continuation, there being no neceſſary Connexion betwixt Time or Place, and the Being or Faculties of Things; and conſequently their Preſervation is owing to ſome Power above thoſe of Matter, *i. e. to him in whom we live, move, and have our Being.*

§ X. But that Argument for the *Exiſtence* of a *Being infinitely perfect*, who made and governs this *Syſtem* of things, which of all others affects me moſt, is that it is altogether impoſſible, this Univerſe cou'd have been better contriv'd or more compleatly finiſhed, than it is, had *infinite Wiſdom* firſt actually deſign'd it, and then put the Deſign in execution. Or which is the ſame, there are legible and indelible *Characters* of *infinite Wiſdom*, in the *Contrivance* of the whole, and of the ſeveral Parts of this admirable Fabrick of the *Univerſe*; and it is altogether impoſſible for the united skill of Men and Angels, to mend any one Part, or to contrive it better, or even to find out any real Defect therein, due Regard being had to the univerſal Benefit of the whole

Syſtem; for in the Contrivance and Adjuſtment of the ſeveral Parts of this noble Machin, where the Choice is various, and ſometimes infinite, that one is pitch'd upon, which alone cou'd bring, the moſt advantages to the whole, or which only cou'd bring about the deſign'd Effect. This is a very large Subject, and to treat it according to it's Dignity requires more Room, than the Limits I have preſcrib'd to my ſelf will admit. However, I ſhall endeavour to illuſtrate the ſame in the following Particulars. But firſt of all it will be convenient to lay down a general *Scheme* of this noble Structure.

§ XI. Let us then conceive the *Mundan Space*, or the univerſal Place of all Bodies, to be boundleſs in it's Extent, or indefinite in its Dimenſions, and in it at vaſt Diſtances from one another, the fixt Stars (huge luminous Bodies, like the Sun) to be plac'd, keeping always the ſame Diſtances from one another, and moving only (perhaps) about their own *Axes*;

about each of theſe let us imagine ſeveral Bodies like our *Planets*, rowling in ſeveral *Orbits* at ſeveral Diſtances; and about thoſe leſſer ones *Analogous* to the *Satellits* of our *Planets*. Each of theſe fixt Stars with their Circumambient *Planet-like Orbs*, conſtituting that which is call'd a *Syſtem* of the *Celeſtial* Bodies. And how many ſuch there muſt be in the vaſt Extent of Space, a naked eye in a cloudleſs Night, may give us ſome faint *Glimps*, but much more a good large *Teleſcope* directed toward that Region of the Skie, which is call'd the *milky way*. Our Numbers fall very ſhort here, and our *Arithmetick* can ſcarce give us an *idea* of the vaſt Quantity of *Syſtems* that adorn this *ſtupenduous* Piece of *ArchiteƐture*; and yet no doubt their Number is finit, and they are all included in a bounded Extenſion; for Matter ſeems not capable in it's Nature of being infinitely propagated. Moreover, let us conceive the glorious Body of the Sun, fixt in the Center of Gravity (or near it) of this our *Syſtem*, and in the common Center of Motion (or *focus*) of all the *Planetary Orbits*. And then next to him *Mercury* makes his *oval round*, but ſo near him, that we can rarely obtain a diſtinct View of him, he being ſwallow'd up almoſt, in the Light of the *Sun*. Next to *Mercury*, is our beautiful Morning and Evening Star *Venus*: next *Venus*, our *Earth*, with it's Attendant the *Moon*, perform their friendly Courſe, and meaſure out the Year. Beyond our *Earth* *Mars* ſingly and alone, revolves about the ſame Center; next to *Mars*, *Jupiter*, the largeſt of the *Planets*, with his four *Satellits* turn round in concert; and laſt of all, *Saturn* with his five Guards, and his ſurrounding *Annulus* or *Ring*, deſcribes the remoteſt *Orbit*, and concludes our *Syſtem*.

§ XII. For the eaſe of the Reader, in going through the following Parts of this Diſcourſe, I ſhall ſet down here the Numbers that repreſent the *Periods*, the *Diameters*, *Diſtances*, *Gravities*, and Quantities of Matter, in thoſe of the *Celeſtial* Bodies, which have afforded any Grounds for determining the ſame, as Mr. *Whiſton* has calculated them from the lateſt Obſervations, by Mr. *Newton*'s Rules.

The Periodical Times of each Planet's Revolution about the Sun.

		Y.	D.	H.
Mercury	Revolves about the Sun in the Space of	00	088	00
Venus		00	224	18
The *Earth*		00	365	06
Mars		01	315	00
Jupiter		12	000	00
Saturn.		30	000	00

The middle Diſtances of the Planets from the Sun.

Mercury	Is diſtant from the Sun.	020952000	Statute Miles each 50000 *Paris* Feet.
Venus		039096000	
The *Earth*		054000000	
Mars		082242000	
Jupiter		280582000	
Saturn.		51354000	

The Quantity of Matter in, and the Gravity of ſuch of the heavenly Bodies (as afford Means for the determining the ſame,) at the ſame diſtance from the Center of the Sun, is as follows,

The *Sun's*	66690
Jupiter's	00060 $\frac{1}{2}$
Saturn's	00028 $\frac{1}{4}$
The *Earth's*	00001
The *Moon's*	00000 $\frac{1}{26}$

The Diameters of the Sun and Planets.

The *Sun's*	494100	Statute Miles each 5000 *Paris* Feet.
Saturn's	043925	
Jupiter's	052522	
Mars's	002816	
The *Earth's*	008202	
The *Moon's*	002223	
Venus's	004941	
Mercury's	002717	

The weight of Bodies on the Surface of the Sun and Planets.

On the Surface of	The *Sun*	10000
	The *Earth*	01258$\frac{1}{2}$
	Jupiter	00804$\frac{1}{2}$
	The *Moon*	00630
	Saturn	00536

The Denſities of the Celeſtial Bodies.

The *Moon*'s	700
The *Earth*'s	387
The *Sun*'s	100
Jupiter's	076
Saturn's	060

The Periodical Times of the Satellits of Jupiter.

1	2
1 d. 18 h. 28$\frac{3}{5}$	3 d. 13 h. 17′$\frac{7}{10}$.

3	4
7 d. 3 h. 59′$\frac{3}{5}$	16 d. 18 h. 5′$\frac{1}{5}$.

The

The Diſtances of the Satellits from the Center of Jupiter.

	1	2	3	4	
Flamſted by the Eclipſes of the Satel.	5. 578	8. 876.	14. 159.	24. 903	Semidiameters of *Jupiter.*
From the Periodical Times.	5. 578	8. 873.	14. 168.	24. 968	

The Periodical Times of the Satellits of Saturn.

1	2
1 d. 21 h. 18′ 31″.	2 d. 17 h. 41′. 27″.
3	**4**
4 d. 13 h. 47′. 16″.	15 d. 22 h. 41′ 11″.
5	
79 d. 7 h. 53′ 57″.	

The Diſtances of the Satellits from the Center of Saturn.

1	2	3	4	5	
$\frac{9}{40}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$3\frac{1}{2}$	12.	Diameters of the Ring of *Saturn.*

The middle diſtance of the Earth and Planets compar'd with their Periodical Times.

	♄	♃	♂	♁	♀	☿
According to obſervation.	954198	522520	152350	100000	72398	38585.
According to the Periodical Terms	953806	520116	152399	100000	72333	38710,

The Times of the Revolutions of the Sun and Planets about their Axes.

The *Sun* in 25 Days	*Jupiter* in 10 hours
The *Earth* in 1 Day	*Mars* in $24\frac{2}{3}$ hours
The *Moon* in 29 Days	*Venus* in 23 hours.

§ XIII. What a *beautiful Scene* of things have we here? How ſimple, and yet how wonderful are the Works of Nature? Such like are all the Effects of infinite Wiſdom, her Foundations are plain and ſimple, but her *ſuperſtructure*, various and wonderful. Her Cauſes few, her Effects innumerable. Her Courſe the eaſieſt and ſhorteſt Poſſible, and her Means the feweſt that can poſſibly bring about her Ends. Let us but conſult the Books of the old *Aſtronomers*, and we will then have ſufficient Ground to admire the frugal Simplicity of Nature, in this neat, compact *Syſtem*; we ſhall ſee there what ſorry, perplext Work they made, with their *Cycles*, and *Epicycles*, their *carrying*, and *æquating*, their *Concentrick* and *Excentrick* Circles, the *Stations* and *Retrogadations*, their ſolid *Orbs*, and the perpetual Change of the *Axe* of Motion, in the celeſtial Appearances: ſuch a ſtrange *ungeometrical* and contradictory *Syſtem* they made of the *Heavens*; whereas from theſe few plain and ſimple Poſitions, all the Appearances of the *Heavens*, are accounted for, with wonderful Conſiſtency and Facility.

§ XIV. The *Sun* being a huge Body of *liquid Fire*, brought into fuſion by the Force of his Heat, and thereby ſending out *Oceans* of that thin, active Fluid, which is the *Medium* of Light, and the Cauſe of all Heat, turns round his own

Axe, from Weſt to Eaſt in about twenty five Days; which ariſes from his firſt Being put into ſuch a *Circumgyration*, after his having been ſeated in his Place. And there being little or no Reſiſtance in his Region to retard his Motion, it has continu'd ever ſince, and will do, till the *Conſummation* of all things; by Virtue of that firſt impreſs'd *Gyration*, and the firſt Law of Nature. His Motion about his own *Axe*, has been diſcovered by *Spots* on his Surface, and his Fluidity, from his leſſer Denſity in reſpect of ſome of the ſolid *Planets*, (ſome ſolid Bodies being more denſe than any Fluid can be) his *Sphæricity*, and that all Bodies heated to ſuch a Degree, as the *Sun* muſt neceſſarily be, muſt certainly be *vitrify'd*. His greater Quantity of Matter, and larger Dimenſions in reſpect of the *Planets*, makes him ſufficient for all the Expenſes of Light, he lays out upon them, whereby his Bulk and Heat is conſtantly diminiſhing, as alſo, for drawing all the reſt of the *Planets* and their *Satellits* towards him; for as has been formerly inſinuated, the Force of *Attraction* of one Body upon ſeveral others, at the ſame Diſtance, is as their *Maſſes*, or Quantities of Matter: Wherefore ſeeing the *Sun* contains a greater Quantity of Matter by very far, than any of the *Planets*, the Sun muſt neceſſarily draw the *Planets* with their *Satellits* to him; which wou'd have unavoidably come to paſs, had not the *Planets* at the inſtant they were ſeated in their Places, receiv'd an impulſe, which drove 'em along the *Tangents* of their *Orbits*; this with the ſmall Reſiſtance they meet in their Courſes, and the Force of the Attraction diminiſhing as the Squares of their Diſtances increaſe, *reciprocally*, has made 'em ever ſince revolve in their *Elliptick Orbits*, in one of whoſe *Foci* the *Sun* is ſituated: And what is here ſaid of the Cauſe of the *Primary Planet's* Motions about the *Sun*, may be underſtood of the *ſecondary Planets* Motions, about the *Primary ones*. All the *Planets* revolve about the *Sun* in *Elliptick Orbits*, or ſuch as are not very far different from them; as alſo moſt of 'em, turn round their own *Axes* from Weſt to Eaſt, the *Earth* in twenty four Hours, about an *Axe*, which is inclin'd to the Plane of the *Ecliptick* 66 ½: and in it's motion about the *Sun*, this *Axe*, of the diurnal Rotation obſerves always a *Paralleliſm* with itſelf, the Reaſon of which is evident, for if a *Sphere* move about an *Axe*, this *Axe* (there being no other Motion ſuppos'd in the *Sphere*) is immoveable, while in the mean time every Point in the *Sphere*, deſcribes a Circle about this *Axe*, and therefore if a *Sphere* move either in a *curve*, or ſtrait Line, and at the ſame time turn round it's *Axe*, the *Axe* ſhall always continue *parallel* to that Line it was firſt *parallel* to; for that Impreſſion which perpetuats it's Rotation upon it's *Axe*, and the impulſe along the *Tangent* of it's *Orbit*, are two diſtinct Motions, which never interfere, and ſo each of them muſt continue the ſame as if the other were not; ſo that every Body turning about its *Axe*, and at the ſame time deſcribing a Right or *Curve* Line, muſt of neceſſity retain it's *Axe parallel* to itſelf, if nothing elſe diſturb it. *Jupiter* likewiſe, *Mars* and *Venus*, and our *Moon*, do alſo turn round their *Axes*, from Weſt to Eaſt, and would retain this *Parallelism*, if not diſturb'd by *Foreign* Violence. The *Satellits of Jupiter* and *Saturn* do likewiſe turn round their *Axes*, as is evident from hence, that they, like our *Moon*, turn conſtantly the the ſame Face or *Disk* toward their *primary Planets*; and it is not improbable, that the others in which we have not had the Occaſion of obſerving the like, may alſo turn round their *Axes*; that in a Revolution about the *Sun*, they may in all their Parts oftner than once enjoy his Light and Heat; for it is from this Rotation of our Earth upon it's *Axis*, that we have the *Viciſſitudes* of Day and Night, and from the *Parallelism* of the *Axis* to itſelf, in the Earth's Revolution about the

Sun, and its being inclin'd to the Plane of the *Ecliptick*, come the beautiful *Seaſons* of the Year, *Summer* and *Winter*, *Spring* and *Autumn*, which is of ſuch comfort and uſe to it's Inhabitants. From the *Opacity* of the *Moon* and *Planets* and their *Satellits*, and the *Obliquity* of their Planes to the Plane of the *Ecliptick*, together with their diurnal and annual Motions; and ſome of 'em revolving in *Orbits*, within one another, their *Phaſes*, their appearing and diſappearing, their total and partial *Eclipſes* ariſe.

§ XV. Since their *Solidity* and *Opacity*, the *Similar* Nature of their *Orbits*, and their *ſatellitious* Attendance, their Revolutions about the *Sun*, and their Rotations about their *Axes*, their *Gravitations* and mutual *Attractions*, the Proportion of their Periods to their Diſtances from the Center of Motion, the *equable* Deſcription of *Area's* in equal Times. Since, I ſay, all theſe and many more Particulars are exactly the ſame in our *Earth*, and the other *Planets* with their *Satellits*, it is not improbable that they may be alike in other things, and that they may have Inhabitants both rational and irrational, Plants and Vegetables, Water and Fire *analogous* to, tho' not of the very ſame Nature and Conſtitution with ours; and ſince our *fixt Stars* are exactly of the ſame Nature with our *Sun*, as ſhall be afterwards made appear, it is very likely that they have *Planets*, and theſe *Planets* have *Satellits*, and theſe *Planets* and *Satellits* have Inhabitants, rational and irrational, Plants and Vegetables, Water and Fire, *analogous* to thoſe in our *Syſtem*. On theſe Suppoſitions, which not only are not abſurd or contradictory; but on the contrary highly probable, as ſhall be afterwards made appear more fully; what a noble and glorious *Fabrick* wou'd preſent itſelf to our Imaginations? How is it poſſible for any one who had this *Idea* of the *Univerſe*, to think it poſſible ſuch a beautiful *Syſtem*, cou'd have been produc'd without infinite Wiſdom? None but the wilful, or obſtinate cou'd reſiſt ſuch a powerful Impreſſion of divine Power and Wiſdom. On the other Hand, how is it poſſible to conceive that, that immenſe Number of glorious and Sun-like Bodies of the *fixt Stars*, thoſe *vaſt* and huge Bodies of ſome of the *Planets* (in reſpect of our *Earth*) with their noble *Attendance*, were made for no other uſe but to twinkle to us in Winter Evenings, and by their *Aſpects* to forebode what little Changes of Weather, or other pitiful Accidents were to be expected below, or to be peep'd at by ſome poor Paltry Fellows of Aſtronomers? Or can any Body force himſelf to think, that all *Animals* and *Plants*, have been exhauſted in furniſhing out this poor Corner, while the other more glorious, great and noble Parts, are left deſtitute and bare? Certainly they muſt have a great Opinion of themſelves, and of their own Habitation, who can think ſo poorly of the reſt of the Univerſe. But allowing the *Planets* to be inhabited, and that the *fixt Stars* have their *Planets* and Inhabitants, yet they are not of the ſame Nature and Conſtitution with thoſe of our Globe, as is evident from the different Degrees of Heat and Light they enjoy; as alſo the different Viciſſitudes of Day and Night, and the Seaſons of the Year. *Mercury* is three times nearer the *Sun*, than we, and conſequently enjoys nine times as much Heat and Light, he never removing thirty eight Degrees from that vaſt Body of Light. *Venus* enjoys twice as much Heat and Light, and her Courſe about her *Axe* is perform'd in twenty three Hours, and ſo her Day is but one Hour leſs than ours; ſhe has all the *Phaſes* of our *Moon*, appearing ſometimes horn'd ſometimes halv'd. *Mars* has no Inclination in the *Axe* of his Rotation to the Plane of his *Orbit*, and conſequently enjoys a perpetual *Equinox*, but no Viciſſitudes of Seaſons; he receives but the third Part of our Light and Heat. *Jupiter* likewiſe enjoys a perpetual *Equinox*, and a Day of ten Hours, but receives only the twenty fifth part of our Heat, and *Saturn* but the hundredth.

§ XVI. The *Satellits* of the ſeveral

Planets ſuffer many and various Diſturbances in their Motions from the *Sun*, as alſo, the Primary *Planets* ſuffer likewiſe from the Forces of the *Sun*, and of the ſecondary *Planets*. Thus the *Moon* (if acted upon only by the attractive Force of the *Earth*) wou'd by a *Ray* from the Center of the Earth, deſcribe equal *Area's* in equal times, wou'd about the *Earth* in one of it's *Foci*, deſcribe a perfect *Ellipſe* of the ſame *Species* conſtantly, whoſe Plane wou'd be immoveable, or always the ſame, and whoſe Inclination to the Plane of the *Ecliptick* wou'd never vary; but by the Action of the *Sun* upon the *Moon*, all theſe Effects are diſturb'd, for ſhe neither diſcribes equal *Area's* in equal Times by a *Ray* from the Center of the Earth, but ſomewhat larger ones in her *Conjunctions* and *Oppoſitions* with the Sun than in her *Quadratures*. Neither is her *Orbit* always *ſpecifically* the ſame, nor is the *Earth* in any of the *Foci* of her *Orbits*; for they are more *Curve* about the *Quadratures*, and leſs toward her *Conjunctions* and *Oppoſitions*, in every Revolution ſhe deſcribes a new kind of *Curve*, and both the Situation of the Plane of her *Orbit*, and it's Inclination to the Plane of the *Ecliptick*, varies every Moment, and all theſe Uncertainties and Aberrations, are multiply'd by her nearer or remoter Diſtances from the *Sun*, beſides a great many other Irregularities too tedious here to relate. Upon the account of all which, it has been ſo very hard for *Aſtronomers*, to reduce her Motions to Rule, and to expreſs 'em in Numbers; and yet all theſe Irregularities are wonderfully accounted for, from the Action of the *Sun* and *Earth* upon her, upon the common Suppoſition of the Law of Attraction, ev'n to a Nicety, beyond which Obſervation cannot diſtinguiſh, as is evident from Mr. *Newton's Theory* of the *Moon*, printed in Dr. *Gregory's Aſtronomy*, which is a ſurpriſing Confirmation of the Truth of that Principle. On the other hand, the Force of the *Sun*, but eſpecially of the *Moon*, diſturbs the Motion of the *Earth*, as is evident from our *Tides*, which do ſo exactly follow the Motions of the *Moon*, that he who knows the former, with ſome few collateral Circumſtances, cannot be ignorant of the latter; for when the *Moon* comes to the vertical Point of any Place, we have a *Tide* there, as alſo on the Place *diametrically* oppoſite to it; this *Tide* is greater at the *Conjunctions* and *Oppoſitions* of the *Moon* to the *Sun*, than at her *Quadratures*, and greateſt of all at the *Equinoxes*, eſpecially if the *Moon* is then in her *Perigeum*, the Reaſons of all which I have ſuggeſted in *the firſt Chapter*. And what is here ſaid of the *Earth*, with reſpect to the *Moon*, may be with due Limitations underſtood, of any *primary Planet*, in reſpect of it's *Satellits*.

§ XVII. That the *fixt Stars* are Bodies like our *Sun*, all the late *Aſtronomers* agree, for it's plain they ſhine by their own Light, ſince it is altogether impoſſible, that the Light of the *Sun*, ſhou'd be ſent to them, and tranſmitted to us, ſo as to make them appear ſo lucid as we ſee them.

We ſee how faintly in reſpect of ſome of the *fixt Stars*, *Saturn* ſhines for all his Bulk; and yet his Diſtance is but a Point in reſpect of the neareſt *fixt Star*, from the *Sun*. The Rays of the *Sun* wou'd be ſo diſſipated before they reach'd ſo remote an Object, that the beſt Eye of the World, cou'd not by it, diſcover them. Their Diſtance is ſo great, that the beſt *Teleſcope*, inſtead of magnifying 'em above what they appear to the naked Eye (as they do any Object, remov'd by any menſurable Diſtance, how great ſoever) does conſiderably leſſen them, ſo that they appear like lucid Points. Beſides, tho' we in this Globe, approach nearer them ſome twenty four thouſand *Diameters* of the Earth, (or 188304000 Miles, allowing five thouſand Feet to the Mile) one time of the Year than another, yet their *Parallax* is ſcarce ſenſible, if any at all, which cou'd not be, if they were at any moderate Diſtance: By Mr. *Hugen*'s Computation, the Diſtance of the *Sun* from us, is to the Diſtance of the neareſt *fixt Star* from us, as 1 to

27664, that is (allowing the Diſtance of the *Sun* from us to be 12000 *Diameters* of the Earth, and a *Diameter* to be of 7846 Miles, according to the beſt Calculations) the Diſtance of the neareſt *fixt Star* from us, is at leaſt 2404520928000 Miles, which a Cannon Bullet moving with the Velocity it has, when parted from the Mouth of the Piece, wou'd ſpend almoſt ſeven hundred thouſand Years to go thro'. Since then, both theſe are true, that they ſhine by their own Light, and that they are at ſuch an immenſe Diſtance from us, it is plain, they muſt be *Bodies* like our *Sun*; which wou'd be evident, cou'd they be brought near us, or we near them, for it is only the Diſtance that creates our doubt. Now this being true, it is impoſſible they ſhou'd be all in the Surface of the ſame *Sphere*, ſince our *Sun* which is one of 'em, cannot be reduc'd to this Rule. Beſides, their different Magnitudes, ſhew that they are at as immenſe Diſtances from one another, as the neareſt of 'em is from us. Let us but imagine our ſelves remov'd at an equal Diſtance from the *Sun*, and *fixt Stars*, we ſhould then certainly perceive no Difference between them; for as to all the *Planets*, that we ſee now attend the *Sun*, we ſhou'd not have the leaſt Glimpſe of them; both becauſe their Light wou'd be too weak to affect us, and becauſe all their Orbs wou'd be united, in that one lucid point of the *Sun*. In this Station, we ſhou'd have no occaſion to imagin any Difference between one *Star* and another, but ſhou'd certainly conclude both *Sun* and *fixt Stars* of the ſame Nature; and knowing the Nature of one, we ſhou'd certainly conclude the ſame of all the reſt, *viz.* that if one was a lucid Globe of liquid Fire, ſo wou'd all the reſt be, and that they were at immenſe Diſtances from one another. Certainly if the *fixt Stars* actually had *Planets*, and they *Satellits*, yet at our Diſtance we cou'd ſee neither. Since then there are ſeveral probable Arguments, (ſome of which I hinted before) that they have Attendant *Planets*, and no poſſible one to evict the contrary, we may ſafely conclude that the *fixt Stars* are ſo many *Suns* in the Center of a *Syſtem* of *Planets* and their *Satellits*.

§ XVIII. Beſides theſe already mentioned, there is another *Species* of Heavenly Bodies, call'd *Comets*, which revolve about the *Sun*; in very Oblong *Elliptick Orbits*, approaching to *Parabolick Curves*. The Times of their *Periodical* Revolutions are very long, ſince in three or four Thouſand Years, we have not poſitively determin'd the Returns of above one or two; however, its certain, that like our *Planets*, they do move in a recurring *Orbit*, that the *Sun* is in one of the *Foci* of this *Orbit*, that by a Ray from the *Sun*, they deſcribe equal *Area's* in equal Times, that the ſame *Law of Gravitation* obtains in them, which does in the *Planets*; that their *Periodical* Times are certain and invariable, and that their Motions are regular, only their Courſe in their *Orbits* is not determin'd one way, but indifferently ſome of 'em move one way, others another: They are alſo about the ſame Bulk with the *Planets*, generally ſpeaking; and like them are compact ſolid Bodies, but ſurrounded with a vaſtly large thin Fluid, intermixt with ſeveral groſſer Particles, and compoſing an irregular unequally diſpoſs'd, and uncertainly agitated Maſs; which is call'd its *Atmoſphere*, whoſe *Diameter*, is ten or fifteen Times as long as that of its Body. Beſides which, it has a long lucid *Train*, which is rais'd in its Approach to the *Sun*, by the Heat thereof, and extends ſometimes to four hundred Thouſand Miles above its Body. It is always oppoſite to the *Sun*, becauſe it is the thiner part of its *Atmoſphere*, extremely rarified by his Rays; and ſo rare that the *Stars* may be ſeen through it. This *Tail* accompanies it through its Courſe over all the *Planetary Regions*, encreaſing in its Approach to the *Sun*, and leſſening in its Receſs. Theſe *Comets* ſometimes come ſo near the *Sun*, as to be heated to ſuch a Degree that they cannot become cool again, in many Thouſands of

Years. This with its violent Motion in a *Curve*, which comes near to a ſtreight Line, after it has paſs'd its *Perihelium*, and the irregular Diſpoſition of the confuſs'd Maſs of its *Atmoſphere*, makes it an unfit Habitation for Animals, that are not in a ſtate of Puniſhment, ſo far as we can conceive of the Nature of Animals. And therefore ſome have thought it deſign'd, to ſupply the Expence of Fluids in the *Sun* and the *Planets*. But as I have before hinted, this does not ſeem ſo very probable, becauſe Nature always ſupplies conſtant and regular Expences after a conſtant and regular Manner. Now the Returns of theſe Bodies are ſo irregular and uncertain, and we ſo little feel the Effects of theſe Returns (which of neceſſity muſt be felt, if theſe frightful Bodies made the *Reimburſement* mention'd, ſince the *Sun* and *Planets* are recruited all at once, or in a very ſhort time, of all the loſs they have ſuffer'd in their Fluids for many Years before,) that I am afraid no ſuch benign Influences, are to be expected from them. I readily grant, that there may be ſome Clouds of Vapours ſweep'd off the *Tails* of theſe *Comets*, by the *Sun* and *Planets* as they approach them. But then, it is uncertain of what Nature theſe Vapours are, for every Vapour will not become a Fluid, unleſs its Parts be of ſuch a determin'd *Figure* and *Size* as the Nature of Fluids require. Now it's certain, that Heat will raiſe any Body into a Vapour, provided it be ſufficient to diſſolve the Union of its Parts, and increaſe their Bulk to a neceſſary Dimenſion: Moreover its hardly accountable how the *Sun* ſhou'd draw from thence only the Fluid of Light, the Earth, that of Water, the other *Planets* their proper Fluids; or if they were ſuppoſ'd to draw all *promiſcuouſly*, how theſe Effects can anſwer the Deſign, ſince Water in the *Sun*, which wanted only more of the Fluid of Light, wou'd be as improper a Gueſt, as Fire on the Earth, which wanted only more Water. I think it is more probable, that theſe frightful Bodies are the Miniſters of *Divine Juſtice*, and in their Viſits, lend us *Benign* or *Noxious* Vapours, according to the Deſigns of Providence: that they may have brought, and may ſtill bring about, the great *Cataſtrophes* of our *Syſtem*, by raiſing of *Tides*, changing the Figures, and the Poſitions of the *Planets*, and the very Nature of the *Orbits* themſelves: and that they may be the Habitation of *Animals* in a ſtate of Puniſhment; which, if it did not look too *notional*, there are many Arguments to render not improbable. But as for the Diminution of the Quantity of Fluids in the *Sun* and *Planets*, it is certainly ſo ſmall and ſo inconſiderable (tho' ſtill it be ſomething) that it will never be ſenſible in any finite Number of Years, and ſo needs not ſo magnificent an *Apparatus*, as the viſit of a *Comet* to ſupply it; as to the Diminution of Light, I do believe it may be demonſtrated, that if all the Fluid which the *Sun* loſes in a Year were brought into a ſolid Form, it would not equal a Grain of Sand. Now what is that to the vaſt Body of the *Sun*? And as for the Fluids on *our Globe*, tho' ſome of them be reduc'd into a ſolid Form, yet upon Examination it will be found that moſt of the ſame is again diſſolv'd into a Fluid; for in all *Animals* and *Vegetables*, the Matter is plain; and as for *Minerals* and *Metals*, I doubt much, whether there be very many new Productions or Generations of that kind, ſince their firſt Production. So that tho' there be ſome loſs of Fluids on *our Globe*, yet there is ſtore enough to ſupply all the Uſes of Life and Vegetation, for any finite number of Years; and by the Frame, and make of this our *Syſtem*, it does not ſeem deſign'd to laſt for ever, without ſome conſiderable Changes.

§ XIX. Thus I have given a ſhort View of this *Syſtem* of things, as it is at preſent, and I am of Opinion it is pretty near the Truth. And now let any one ſeriouſly reflect upon the *Vaſtneſs*, *Magnificence*, *Beauty*, *Order*, and *Symmetry* of this *Scheme*, and try if he can think it the Effect of Chance, or, if he can ſo much as doubt, that ſome infinitely wiſe and powerful *Architect* has rear'd this noble *Fabrick.* But to drive the Argument farther, let us enquire a little into the particular and obvious *Deſigns* and *Contrivances* of this Divine *Architecture.* And 1. It is plain from what has been ſhewn, that the univerſal Principle of *Attraction* or *Gravitation* obtains in all the Bodies of this Univerſe; and that the Motions of all the *Planets*, their *Satellits* and the *Comets*, are govern'd by one Condition thereof, *viz.* that the Force thereof at different Diſtances from the Center of Attraction, is *reciprocally* as the *Squares* of theſe Diſtances. Now is it at all probable that ſo *univerſal a Law*, ſo powerful a *Principle*, and ſo conſtant a Rule ſhou'd be owing to Chance? If one with 10000 Dice, ſhou'd throw 5000 Sizes, once or twice, or even 1000 Sizes once and again, we might poſſibly ſay he did it by Chance; but if with an almoſt infinite Number of Dice, he ſhou'd always without failing throw the ſame ſide in 'em all, we ſhou'd certainly conclude,

clude, he either did it by *Art* and *Contrivance*, or that theſe Dice cou'd turn up on no other ſide. Now I have demonſtrated that *Gravitation* is not *eſſential* to Matter, and ſo it might have been without it; and yet all the Bodies of the Univerſe, ſo far as we can diſcover, are endow'd with this Principle; and therefore, it was deſign'd by him who laid the Foundations of the World. 2. It is worth our Obſervation to take Notice, how conſtant and beautiful a Proportion, the Times of the Revolutions of all the *Planets*, and their *Satellits*, keep to their *middle Diſtances*; for univerſally, in all the Revolutions of the *Planets* about the *Sun*, and of the ſecondary *Planets* about the *Primary* ones, the *periodical Times* is in a *Seſquialter* Proportion to the *middle Diſtances*; or the *Cubes* of the middle Diſtances, from the Center of their Motions, are in all of them (*Planets* and *Satellits*) as the *Squares* of the *Periodical Revolutions*. 3. All the *Planets* by Rays from the *Sun*, and all the *Satellits*, by

Rays from their Primary *Planets*, deſcribe equal *Area's* in equal Times, *i. e.* the *Area's* deſcrib'd, are always *proportional* to the Times. So that when they approach to the Center of their Motion, they move faſter, and when they recede from it, ſlower; ſo as to compenſat their Nearneſs, by their Swiftneſs, and their Diſtance by their Slowneſs: Always making up equal *Area's* in equal Times. Theſe two ſo *univerſal*, and ſo *regular* Affections, of the Motions of the *Celeſtial* Bodies, are not only diſcoverable by Obſervation, but are the neceſſary Effect, of the Law of Gravitation, juſt now mentioned to be the *Principle* of the Heavenly Motions. Can any Body now, who conſiders how many things are concurring to, and depending upon theſe beautiful *Proportions*, and regular Effects, ſo much as once queſtion whether they are the Product of infinit Wiſdom? Certainly nothing leſs cou'd be ſufficient, to make the *Calculations*, adjuſt the *Forces*, and determine the *Powers*, neceſſary towards the Production, of ſuch exact and regular *Effects*. 4. All the *Planets* are ſo wiſely ſituated, in reſpect of the *Sun*, that the Denſer *Planet*, is ſtill neareſt him, and the leſs Denſe, is farther remov'd from him; and the leaſt Denſe of all, is the moſt remote. Now can any Body think this was ſo ordered without *Deſign*? No certainly, it is ſo obvious no Body can miſs of it; for it is plain the more Denſe Matter requires a greater Degree of Heat, to fit it for natural Productions; and the leſs Denſe, needs only a leſſer Degree of Heat, for the ſame End. And conſequently, their Diſtances were adjuſted for this very Reaſon; and this by the bye, is a very good Argument for the *Planets* being inhabited, ſince according to their Denſities, they are fitted with Degrees of Heat neceſſary for natural Productions, now this Adjuſtment and theſe natural Productions were uſeleſs, if there were no Creatures to enjoy the Benefit of 'em, and we all know Nature has done nothing in vain. And therefore ſince theſe *Accommodations* are provided for living Creatures, there are ſuch certainly to enjoy 'em. 5. The *Velocity* of the *Planets* Motions, is ſo adjuſted in reſpect of the *Sun*, and the *Velocity* of the *Satellits*, in reſpect of their *primary Planets*, that the *Planet* which is neareſt the *Sun*, moves faſteſt, and thoſe more remote, leſs faſt, and the fartheſt, ſloweſt of all. And ſo in the *Satellits*; the neareſt to the *primary Planets*, moves quickeſt, and the remoteſt, ſloweſt. For ſince the *Centripetal* Forces, are *reciprocally*, as the *Squares* of the *Diſtances* from the Center, and the *Celerities* in that caſe, reciprocally, as the *ſquare Roots* of the Diſtances from the Center; and ſince the ſquare Root of the remoter Diſtance is greater, than the ſquare Root of the nearer, therefore the Velocity of the nearer, is greater than that of the remoter. Now this is a wiſe *Contrivance* of the *Author* of *Nature*; for ſince the nearer *Planet* enjoys more of the Heat of the *Sun*, than the remoter, it was fit the Viciſſitudes of the

Seaſons, ſhou'd be quicker, that anſwering beſt the Ends of natural Productions; for ſince their Diſtances are leaſt, and their Velocities greateſt, that are next the *Sun*, their *Periods* muſt be ſhorteſt; and ſince they all move about their *Axes*, moſt, if not all of them, making thereby ſome *Angle* or other with the Plane of their *Orbit*, they muſt admit of Variety of Seaſons; and where the Heat is greateſt, there for the Conveniency of natural Production, it was neceſſary the Seaſons ſhou'd be ſhorteſt, where the Heat is leaſt, there the Seaſons ſhou'd be longeſt: Now all theſe Effects are taken care of by this adjuſting of the Velocity to the Diſtance. And what is here ſaid of the Seaſons in reſpect of the *Planets*, may be underſtood of the *Satellits* Influences, from their *primary Planets*; for whatever Effects the *primary Planets* produce on the *ſecondary* ones, it is doubtleſs moſt convenient, the Viciſſitudes thereof ſhou'd be quickeſt, in the neareſt, and ſloweſt in the remoteſt *Satellits*. And this, as well as the former, is a convincing Proof of the *Planets* being inhabited; for all this beautiful Contrivance is loſt, if there be no Inhabitant in theſe *Celeſtial* Bodies to enjoy the Benefit of it. 6. All the *Planets*, deſcribe about the *Sun* in one of their *Foci*, *Elliptick Orbits* of one Species or another; and all the *Satellits* deſcribe about their *primary Planets* in one of their *Foci*, *Elliptick Orbits* alſo; and the Planes of all the Orbits do very nearly coincide with one another, and with the Plane of the *Ecliptick*. That the *Planets* deſcribe *Elliptick Orbits* about the *Sun*, there is no manner of doubt now among *Aſtronomers*. And tho' they ſay, that the *Orbits* of the *Satellits* are not exactly *Elliptical*, yet that is from neceſſary Cauſes, and is not owing to Chance, but to the already eſtabliſh'd Laws of the Univerſe; yet ſtill their *Orbits* are nearer *Ellipſes* than any other *Geometrical Curves*, and may be reduc'd to theſe; and that the Planes of the *Orbits* of the *Planets* coincide with the Plane of the *Ecliptick*, and with one another nearly, is matter of Obſervation. Now is it imaginable, this beautiful and conſtant Order of theſe three things, of *Elliptick Orbits*, the Situation of the *Sun* in the one of the *Foci*, and the Coincidence of the Planes, of the *Orbits*, with that of the *Eclip-tick*, cou'd have been the Effect of Chance and Caſualty? Or that it was without Deſign or Counſel? No certainly, for the Advantages thereby ariſing to our *Earth* in particular, are evident; for thereby, the colder and more Northern Places of our Globe, are brought ſome hundreds of thouſand Miles, nearer the *Sun* in Winter, than in Summer; which cannot but be of ſome uſe to thoſe Places, that by the natural Courſe of the Earth, are depriv'd of the benign Influence of the *Sun* at that Seaſon. Now this Benefit wou'd be conſtant if the Place of the *Perihelium* did not change; but ſince that is not conſtant, the other is not durable, but temporary. But this change is not now to be taken notice of, ſince it is a Queſtion if theſe Irregularities were any part of the firſt Contrivance of this Univerſe. Now tho' in the reſt of the *Planets*, the Situation of their *Perihelia*, is not the ſame; yet nothing is to be concluded from thence, againſt this Argument, ſince we know not the Nature of their Inhabitants, nor of their Natural Productions: But this we may conclude, ſince it is of notable Uſe to one of the *Planets*, it cannot be amiſs to any of 'em, they agreeing in moſt things: But whatever be the Deſign thereof, yet the conſtant Order of theſe things are a ſufficient Proof that they were not Caſual, but the work of Infinite Wiſdom, 7. The *Sun*, all the *Planets*, and their *Satellits*, ſo far as we have had occaſion to know, move about their own *Axes*, the *Axe* of this Rotation is alway *parallel* to itſelf, and they revolve all one way from Weſt to Eaſt, and that in Planes, almoſt coincident with one another, and that of the *Ecliptick*. As to the *Rotation* about their own *Axe*, it is matter of Obſervation in the *Sun*, the *Earth*, *Mars*, *Jupiter*, *Venus*, the *Moon*, and it is very probable in the other two; and as to the *Paralleliſm* of the *Axe* of their Rotation, it is demonſtrable *à priori*, as I have formerly ſhewn, and wou'd be nicely exact, if the ſame were not diſturb'd by ſome collateral Cauſes; as alſo the Coincidence of the Planes of this Rotation, with one another, and with the Plane of the *Ecclip-tick*, is ſo very near the Truth, that the ſmall Difference from it, is not to be regarded. Now can theſe conſtant and regular Effects be aſcrib'd to any thing, but an over-ruling Providence? Can Jumble, and Confuſion produce regular and invariable Effects? It is altogether impoſſible, and therefore, nothing but the Author of Light, and Order, and Beauty, cou'd have brought about ſo uniform, and ſuch conſtant Effects. Farther, let us now conſider, that all theſe beautiful and comely *Proportions*, all theſe conſtant and immutable *Effects*, all theſe uniform and regular Appearances, which agree, not to a few things, or in ſome particulars, but in moſt of them, to all the *Planets*, to all their *Satellits*, to the *Sun*, and the *Moon*, and the *Comets*, and in a word, to every thing in this our *Syſtem*, might have been varied, ſeveral and diverſe ways; and yet none of 'em fitted ſo well, to the preſent ſtate of things, and the univerſal Benefit of the whole *Syſtem*, as theſe already ſettled. Thus there might have been an *infinity* of different, poſſible Laws of *Gravitation*, yet none of them wou'd have fitted our preſent Circumſtances, ſo well as to the *Reciprocal Duplicat*. There are innumerable *proportions*, beſides the *Seſquialter*, yet none of 'em had ſuited us ſo well, becauſe this is the Effect of the Law of Gravitation, and on theſe two, all the ſubſequent Advantages from the preſent eſtabliſh'd Motions of the *Planets* depending, any other different from theſe wou'd have depriv'd us of thoſe Advantages. The various poſſible Diſtances of the *Planets* from the *Sun*, the poſſible Times of their *Revolutions*, their poſſible

Celerities; the poſſible *Figures* of their *Orbits*, and of the *Inclinations* of their Planes to one another, and to the Plane of the *Ecliptick*, their poſſible *Denſities* and *Bulks*, and the poſſible *Changes* of their many other *Affections*, are in number infinite; and yet I have ſhewn that moſt of theſe as they are at preſent, bring very conſiderable Advantages with them, to the *Syſtem* in general, which conſequently wou'd be loſt, were they diſpos'd after another manner. Add to theſe, that all theſe Affections of the *Heavenly Bodies*, might have been in no regular Order, nor conſtant Proportion, at all, and conſequently the poſſible Varieties of the *Celeſtial Bodies* might have been infinite among 'emſelves, and different from thoſe now mentioned. But ſeeing every thing is adjuſted by *weight* and *meaſure*; ſeeing they obſerve *Order* and *Proportion*, and that every one of 'em is diſpos'd in the fitteſt *Order*, the preſent ſtate of things will admit, ſince both the whole and the ſeveral Parts of the *Celeſtial Fabrick*, is both very good, uſeful, and convenient, who that conſiders all theſe things, dares ſo much as doubt whether he who did all theſe things *lives and reigns for ever and ever?* or who can forbear to admire and adore him, who *weigh'd the Mountains in Scales, and the Hills in a Balance, who ſtretch'd the Hea- like a Curtain*, and held the Earth in his Hands, *whoſe right hand*, and *ſtrong Arm does wonderful things paſt finding out.*

§ XX. Having now conſidered, ſome of the more general Affections, of the *Heavenly Bodies*, and of their Motions, and ſhewn ſome of the Advantages, ariſing from their preſent Order and Diſpoſition. I come now to conſider the *Celeſtial Bodies* a little more particularly, and firſt as to the *fixt Stars*, can any thing beget a greater *Idea* of the Univerſe, or of it's Creator, than that *prodigious* number of glorious Bodies, like our *Sun*, rang'd all up and down the *immenſe Vaſt*, and remov'd at Diſtances from one another anſwerable to their Diſtance from us? This, not only their different *apparent Magnitudes*, but likewiſe the number of thoſe of the firſt, and ſecond Rate, does evince; For upon the Suppoſition, that every *fixt Star*, is like our *Sun*, and governs in a Portion of *Mundan ſpace*, equal to our *Syſtem*, then there muſt be only as many *fixt Stars* of the firſt Magnitude, as there are *Syſtems* that can ſtand round ours; but there are but about twelve or thirteen *Spheres*, that can ſtand round a middle one, equal to 'em; and ſo many are the *Stars* of the firſt Magnitude. Again, if we examine how many *Spheres* can ſtand round this firſt Range of *Spheres* we will find their number betwixt forty eight and fifty two, and ſo we find the number of the *Stars* of the ſecond Magnitude. As for the ſeveral other Magnitudes, it is not altogether poſſible to determine their number, becauſe they are not ſo diſtinguiſhable from thoſe of the other Magnitudes, as the firſt and ſecond are. Beſides, I do not plead here for Accuracy, but only for things being nearly ſo; for, I do not think that the *fixt Stars*, are either all of the ſame real Magnitude, or that their *Syſtems*, are all of the ſame Dimenſions: theſe things being nearer any Regular Proportion, than they are to Irregularity, is ſufficient for my Purpoſe; for it is impoſſible for any Body, ſeriouſly to conſider in his Mind, or view with his Eyes, what is certain about theſe glorious Bodies, to hinder himſelf from being raviſh'd with the Power and Wiſdom of the *Great God of Heaven and Earth.*

§ XXI. How *beautiful* and *glorious* a Body is the *Sun*, and of what abſolute Neceſſity to the Being of all *Animals* and *Vegetables!* As to *Vegetables*, it is beyond all doubt, that without him they cou'd never riſe above the Ground; for it is his Heat alone, that rarifies the ſizy Juices about their tender Roots, and makes them force their way, to diſplay all the Foldings of the ſlender Seed, and thereby to augment their Parts; juſt as we find his Heat, raiſes the Liquor in the *Thermometrical* Tubes, and drives them through all it's winding Branches, and tho' perhaps *Animals*, might make a ſorry Shift (ſuppoſing Food cou'd be ſupply'd 'em without his Influence) in a perpetual State of Darkneſs, yet it wou'd be a very miſerable ſort of Life, and cou'd be of no long continuance; for we know, how neceſſary the *Sun* is to purifie our Air, and to exhale the *noxious* Dews, and the baleful Vapours of the Night; we feel a ſenſible Joy in his Light, and Heavineſs in his Abſence; foul Weather, and a cloudy Day, is a Diſeaſe alone, and he who underſtands the *Animal Oeconomy*, knows the Reaſons, and the *Mechanical* Neceſſity of all theſe things. One thing ev'ry Body knows, *viz.* that by the Heat of the *Sun*, and the Action of his Rays, that infinite Number of the *excrecretory Ducts* of Perſpiration, plac'd along all the ſuperficial Parts of the Body are open'd, and enlarg'd, and ſo thoſe Exhalations, which Nature has deſign'd ſhou'd be carry'd out of the Body, are more freely and plentifully deriv'd; which muſt needs give a greater Freedom to the Blood and Spirits, the contrary of all which, happens in the Abſence of this *Benign Star.* But of this more afterwards. It's being ſituated immoveable in the Center of our *Syſtem*, no Body who has been at the pains to conſider the Matter, I believe doubts now, for not to mention at preſent the Controverſie about the *Parallax* of ſome of the *fixt Stars*, which Mr. *Flamſtead* has obſerv'd, and whereby he pretends to demonſtrate the Motion of the Earth, and conſequently the Stability of the *Sun*; there are ſome other Arguments that will have ſufficient Weight to ſettle the Matter among thoughtful Men. For 1. It is altogether impoſſible to account for the Appearances of the *Planets*, their *Satellits*, and of the *fixt Stars*, in any tolerable manner, without admiting the Motion of the Earth. 2. It is likewiſe impoſſible to account for the Motions of the *Comets*, upon any other Suppoſition. And 3. that Analogy of the *Periodical* Times, to the *midle Diſtances*, which is the neceſſary Conſequence of the eſtabliſh'd Law of Gravitation, does demonſtrate the Earth's Motion *à priori*; ſo that unleſs we wou'd ſubvert the whole *Syſtem* of *Aſtronomy*, and diſprove the Cauſes of all the Celeſtial Motions, we ſhall never be able to prove the Stability of the *Earth*. For if the Celeſtial Bodies attract one another in a *duplicate Proportion reciprocally*, to their Diſtances from the Center of their Revolutions, then the *Earth* (and not the *Sun*) moves. Add to all theſe, that there is no tolerable Objection againſt the Earth's Motion, but has had a full Anſwer, and a plain Solution. Now what an Inſtance of Wiſdom and Contrivance is this, in placing that Fountain of Light and Life, in the Center of his *Syſtem*. How unartful wou'd it have been, to have ſet him in a Corner, when he was to have giv'n Light and Warmth to all the Bodies round him; beſides, to the conſervation of any ſuch Suppoſition (ſuch as the *Tychonick* or *Ptolomick*) there are requir'd ſo many different Laws of *Gravi-*

Gravitation, that any reaſonable Perſon by inquiring into them, wou'd eaſily diſcover, that whatſoever was Matter of fact, yet this Poſition of ours was the the moſt ſimple and eaſie, and look'd moſt like the Effects of Wiſdom and Deſign: For here one ſingle Law, accounts for all the various Motions and Appearances of the *Celeſtial Bodies*. Thus then this great and glorious Body is fixt, like a powerful and a kindly *Monarch* on his Throne, diſtributing Light, Warmth, and Life in plentiful Effuſion, to all his ſurrounding *Vaſſals*, and that ſo equally, that the neareſt have not too much, nor the remoteſt too little. Theſe are ſuch great, ſuch wiſe Ends, as clearly ſpeak the *Omnipotence* and *Omniſcience* of their *Author*. Moreover, let us conſider, with how much Artfulneſs his Bulk and Situation, in reſpect of the *Planets*, is contriv'd to have juſt Quantity enough of Matter to draw round him theſe Maſſy Bodies, and their *Satellits*, ſo various in their Bulks and Diſtances from him; and that in regular and uniform *Orbits*. How exactly his Body is rounded, how fully it has been ſaturated with the Fluid of Light, to be able to laſt ſo many Years without any ſenſible Diminution, tho' there are conſtant Emanations thereof upon his Attendents. As for his *Rotation* about his own *Axe*, it is no doubt likewiſe, for wiſe Ends and Purpoſes, perhaps it may be for the better propagating, and emitting this Fluid of Light, through the *Planetary Regions*; but I am rather inclin'd to believe it may be the neceſſary Effect of the Fluidity of his Body, it being very well known, that the Particles of all ſolid Bodies running into fuſion, by the Force of the heat, are turn'd innumerable different ways; and ſo by their Oppoſition and Interferings, are at laſt determin'd, into a circular Motion of the whole one way. However this Matter be, we have here ſufficient Inſtances of Wiſdom and Deſign to enforce upon us the Belief that a being infinitely perfect is the Author thereof.

§ XXII. We can no otherwiſe gather the uſefulneſs of the *ſecondary Planets*, to their *primary* Ones, but by ſuppoſing the reſt may reap *reſpectively*, ſome thing *analogous*, to the Benefits we of the Earth, receives from our *Moon*, which are 1. The ſupplying of the *Sun* in the Night time, for at leaſt three fourths of the Year. Now how comfortable and delightful a thing this is, Travellers and Voyagers can beſt tell, *Curioſity*, *Ambition* and *Luxury*, have now made it neceſſary, that ſome part of Mankind ſhou'd be travelling by Land or Sea, in the Night Seaſons; how pleaſant then, and joyful a thing, is it to have a Light held us forth from *Heaven*, not only to guide our Steps, but to direct us in our Courſe, and to point out to us, how our time wears out? For a very little Experience, makes us reap both theſe laſt Advantages from the Preſence and Motion of the *Moon*. 2. She raiſes our *Tides*, twice in twenty four Hours, which how abſolutely neceſſary it is toward the ſubſiſtance of *Animals* and *Vegetables*, we ſhall now ſhew. Every Body knows that a *Lake* or *Loch*, that has no freſh Water runing into it, will by the heat of a few Months, and its Stagnation, turn into a ſtinking rotten *Pudle*, ſending forth nauſeous and poyſonous Steams; for tho' I do not think, the conſtituent Particles of Water themſelves, are alter'd by this Stagnation, yet no Water is abſolutely pure, but contains a greater Quantity of Fleſhy, Bony, Earthy, Salin, Metallick, and Vegetable Particles, than of pure *Element*; and it is upon theſe, the heat operates, by diſſolving their Union, and combining 'em in new Forms, and ſeparating theſe *noxious* Particles which produce this Effect. Now tho' there be many thouſands of freſh Water Rivers, daily runing into the *Sea*, yet they are very inconſiderable in reſpect of the *vaſt Ocean* of Salt Water, and wou'd by no means hinder it's Stagnation, and conſequently it's Corruption and Stinking. But admit the Ocean once ſtagnated, and then the firſt Effect wou'd be, that all the Places toward the Shores, wou'd be firſt wrought upon by the Action of the *Sun*, and turn'd to a *Mephitis*, and then by Degrees it wou'd get farther, till the whole were become more *baneful* and *poyſonous* than the Lake of *Sodom* and *Gomorrah*; whereby the *Fiſhes* wou'd be firſt deſtroy'd, and by the noxious Steams thence ariſing, afterwards the *Plants* and *Animals*; whereas by this Action of the *Moon*, the Waters are lifted up in a heap, as it were, and then let fall again; whereby the Waters near the Shores, are conſtantly ſecur'd from Stagnation and Corruption, and the begining Malady ſtifled. This perpetual Change of new Water on the Shores, keeping any one Portion thereof, too ſhort a time, expos'd to the heat of the *Sun*, to have it's mixture corrupted. Now what a *noble* Contrivance have we here! by appointing an *Attendant* to our *Earth*, all the *Vegetables* and *Animals* are preſerv'd from certain Deſtruction; (but I am of opinion that to the full effect of this wiſe Deſign, the Salt of the Sea does very much contribute; for as I have ſaid before, and may obſerve afterward, the pointed ſlender Particles of the *Salt*, ſtick the Parts of Bodies ſo together, that the Particles of Heat, cannot ſo eaſily tear 'em aſunder.) Beſides this, how many Conveniencies for our *Navigation*, in Rivers and Harbours, does this ebbing and flowing of the *Sea* afford? No Body that conſiders them, can ceaſe from wonder, or can continue in Unbelief. And here perhaps it will not be amiſs to conſider that if our *Earth* had any more than one *Moon* attending it, that we ſhou'd receive more Damage than Advantage from it; for tho' perhaps thereby our Light in the Night (provided ſhe were of any Bulk, or at any Diſtance near to that of our preſent *Moon*) might be augmented, yet at the *Conjunctions* and *Oppoſitions* with one another, and with the *Sun*, we ſhou'd have Tides that wou'd raiſe the Waters to the tops of our Mountains, and in their *Quadratures* we ſhou'd have no Tide at all. In ſhort, if our *Moon* were biger or nearer the *Earth*, or if we had more than one, at any tolerable diſtance from us, we ſhou'd be every now and then, in hazard of being drown'd; and if our preſent *Moon* were leſs, or at a greater diſtance, or if there were none at all, we ſhou'd be in hazard of being ſtifled by the noxious Steams ariſing from the *Ocean*, which wou'd ſtagnat more than it now does. From all which it's evident how wiſely our *Satellit*, has been contriv'd for our Purpoſes. As for the numerous Attendants of *Jupiter* and *Saturn*, they muſt be reaſonably expected to fit the Neceſſities of the Inhabitants of theſe *Planets*, ſince our Moon ſuits us ſo well, and tho' the Fluids of theſe *Planets*, be not in ſo great hazard of corrupting from the Heat of the *Sun*, yet they may poſſibly be in hazard of being congeal'd by the Violence of the Cold, and the frequent toſſing and turning over of them, by the united, or ſeparated Forces of ſo many *Moons*, may hinder this Effect; for we ſufficiently know, how ſtrongly Fluids in Motion will reſiſt the Efficacy of Cold. However the thing be, we may here obſerve

ſerve one very ſignal Inſtance of *Wiſdom* and *Contrivance*, in placing the Heavenly Bodies at ſuch a Diſtance from each other, and eſpecially the greateſt at the greateſt Diſtance; for had they been ſituated much nearer to one another, they wou'd have caus'd prodigious Diſorders in very different Manners, and in particular ſuch deſtructive *Tides*, where-ever there was any Quantity of Fluids, or great *Oceans*, that neither *Animals* nor *Vegetables* wou'd have been able to ſuſtain their Fury; which by this prudent placing the *Heavenly Bodies*, at ſuch a Diſtance from one another, are intirely prevented. 3. From our *Moon* the *Eclipſes* call'd by her Name proceed, which is of exceeding uſe in *Navigation*; for by them the Differences of *Meridians*, and the *Longitudes* of Places are determin'd. Of the ſame uſe are the *Eclipſes* of the *Sun*, and of the *Satellits* of the other *Planets*; which laſt being ſo frequent, are of wonderful Aſſiſtance, toward the Solution of this ſo deſirable and ſo much deſpair'd of *Probleme*. And upon this Head of *Navigation* all *Aſtronomy* comes in, without which the other were meer groping in the Dark; but the World is already ſo ſenſible of the Advantages ariſing from the Motions and Appearances of the *Heavenly Bodies*, in the Matter of *Navigation*, that I ſhall inſiſt no farther on this *Topick*, but from this whole Section about the Uſe of the *Attendants* of the *Planets* ſhall infer, that they are not mute Perſons, in this great *Drama* of the World, but loudly proclaim the *Wiſdom* and *Being* of their *Author*.

§ XXIII. As to the *Comets*, I have little more to ſay about them, than what I have already ſaid, their *Natures*, *Orbits*, *Motions*, and *Situations*, have been ſo lately determin'd, (indeed it is but of late, that the *Aſtronomy* of the *Planets* themſelves, and their *Satellits* has been brought to any tolerable Perfection, and much later ſince final Cauſes have been cultivated, with that Care becoming ſo noble and uſeful a Part of *Philoſophy*.) and there are ſo few accurate Obſervations about 'em extant, ſo few of 'em, that we know of, have viſited us twice, that we have ſcarce any ſolid Foundation to build our Reaſoning upon. Only, as I have before hinted, theſe *blazing Stars* ſeem not deſign'd for the Habitation of *Animals* in a ſtate of Happineſs, nay ev'n ſcarce of *Animals* not under a State of Puniſhment; they may be the firſt *Rudiments* of *Planets*, not as yet brought into our *Syſtem*, or rather the *Ruins* of ſome baniſh'd thence, to wander in theſe long *Eccentrick Orbits*, through the World. But moſt likely they are the *Miniſters of divine Juſtice*, ſending baleful Steams, from their long Trains, upon the *Planets*, they come nigh; and if what is commonly ſaid of 'em by *Aſtrologers* be true, they ſeldom viſit us without ſome ſuch direful Salutation. However, from them we may learn that the *Divine Vengeance*, may find a ſeat for the puniſhment of his Diſobedient Creatures, without being put to the expenſe of a new Creation.

§ XXIV. Come we now to enquire into the Wiſdom of the Contrivance of the *Planets*. But having already ſhewn the *Analogy* between them and our *Earth*, and how probable it is that they are inhabited by Creatures fitted for ſuch Habitations, I ſhall content my ſelf with pointing out ſome of the moſt conſiderable Inſtances of *Deſign* and *Wiſdom* in this our *Planet*; hoping the Reader will reaſon after the ſame manner (bateing particular Circumſtances) of the reſt, and that, both becauſe the deſign'd Brevity of this Treatiſe will not permit me to be ſo particular, as the Subject deſerves, and becauſe, if the *Analogy* hold in general, the particular ones (with allowance for Circumſtances) will eaſily follow. And firſt let us conſider the Advantages, ariſing to us by the *Rotation* of the *Earth* about it's own *Axis*. We the Inhabitants of this Globe are ſo made, that once in ſixteen or twenty Hours at moſt, we require a Time for *Relaxation*, and generally ſpeaking, in all healthful People this time is pretty equal, between ſix and nine Hours, the Store-houſes of our Spirits will not permit any longer Application than twenty Hours, without Injury to our Conſtitutions, and much about the Time of ſix Hours is requir'd to fill 'em again; and generally ſpeaking, it is neceſſary that an Alternation of *Application* and *Relaxation*, ſhou'd be once in twenty four Hours. It's true Cuſtom and Education, may get the better of theſe *natural Propenſities*, and a very ſtrong Conſtitution may bear out with harder Meaſures for ſome time; but the Young, and the Weak, and almoſt all at their own Liberty, naturally run into a *Relaxation*, and recruiting their Spirits by Sleep, once in twenty four Hours. It was likewiſe neceſſary, that the Air ſhou'd be at leaſt cool and temperate, during the time of this Reſt, for we generally find thoſe that ſleep in the open Air, or ev'n while the *Sun* is above the *Horizon*, the worſe for it; the *Sun* and Heat exhaling the natural Perſpirations too violently, and raiſing too quick a Motion, in the Blood, whereby the Sleep is leſs calm, and more diſturb'd. And tho' we generaly perſpire more in the Night than the Day, yet this is more natural, and leſs violent, and more according to the Neceſſities of our Conſtitution, in the Night than the Day. Beſides, that of neceſſity, the Darkneſs is leſs ſubject to Noiſe and Diſturbance, than the Day. Now all theſe things are wonderfully provided for by the *Rotation* of the *Earth* about its *Axis*; for thereby we have the *Viciſſitudes* of Day and Night, the Day for *Application* and ſpending our Spirits in, about the Neceſſities of Life, the Night by its Coolneſs and Quiet, to afford us time to recruit 'em, and lay up in ſtore, for the Expenſes of the next Day; as alſo for nouriſhing the Muſcles, Bones, Channels, and the other Parts of the Body; for the Buſineſs of Nutrition is moſtly, if not altogether perform'd in the time of Reſt, becauſe the Blood has too rapid and quick a Motion, the Expenſes of the Spirits are too great, to afford Leiſure, or Materials for nouriſhing the Parts in the time of Application: Beſides that a gentle uniform Motion is requir'd to apply nouriſhing Parts, to the neceſſary Places, and to ſettle 'em there; and we generally find that People recovering from a Diſeaſe, and Children, ſleep more, and are more fed by their Sleep, than any other *Animal Function*, and groſs People naturally ſleep longeſt. Likewiſe, what a comfortable and refreſhing thing is the cool Breezes of the Night, to thoſe that live under the *equatorial Parts*, without which Life wou'd be both exceeding ſhort, and very grievous. Moreover, let us reflect upon the Neceſſities of our *Vegetables*, which are the Support of Animals; we have before ſaid, that the Heat of the *Sun* rarifies, and conſequently raiſes the ſizy Juices, at the Roots of the tender Seeds, and thereby forces the folded Branches to expand and enlarge. Now were the *Sun* conſtantly, or for any long time, ſhining upon them; theſe Juices wou'd not be at liberty to ſettle, and conſolidate in the fit Places of the Branches; but wou'd be ſtill riſing higher and higher, till at laſt they burſt the Tops of the Canals, and conſequently cou'd produce nothing; whereas by this *Viciſſitude* of Heat and Cold, what is rais'd in the Day-time, has time to ſettle and conſolidate in the Night, and it's Cold runs the thin Juices firſt into thick, ſizy, Subſtances, which the ſupervening Heat, by exhaling the watery Parts (which are now brought nearer the Surface of the *Plant*) does harden and fix. This we evidently ſee in *Nutgals*, and the other Excreſcences of the Leaves of *Vegetables*; and generally, Countries that have moderately cool Nights, produce *Vegetables* of the firmeſt Union of Parts; and very hot Countries, ſuddenly bring up their Seeds, but their Parts are leſs firmly ſtuck together; they may be heavier, but not ſo tough or hard, tho' this too depends much upon the Conſtitution, and firſt make of the Seed. On the other Hand, had not the *Earth* mov'd upon its *Axe*, but only turn'd round the *Sun* in its *annual Period*, we had not only loſt all theſe Advantages, which are ſo beneficial, if not abſolutely neceſſary to the Being of our *Animals* and *Vegetables*, but we had ſuffered alſo ſuch Inconveniences, as neither of theſe cou'd poſſibly bear; for then, for very near one half of the Year we ſhou'd have been in perpetual Darkneſs, the Conſequence of which wou'd have been, that firſt baleful and ſulphureous Damps (by the Forces of the preceding Heat generated and rais'd.) wou'd have fall'n, which wou'd have ſtifled all the *Animals*, or had they ſurviv'd that, by Degrees, exceeding Rains wou'd have been pour'd down (as the Vapours became cooler) next Sleet, then Snow, and Ice, and Froſt, which wou'd of neceſſity, not only have lock'd up all Fluids, but wou'd have freez'd the Blood and Spirits in the Channels, of all the *Animals* we are acquainted with; for as I have ſhewn before, there is a ſaline Body conſtantly ſwiming in our Air, which by the Preſence and Action of the *Sun*, is ſo attenuated and reduc'd into ſo ſlender Particles, whoſe Points (being eaſieſt broken) by the Force of the Fluid of Light are firſt beat off, as not to be able to do any Damage, but in *his* Abſence, they ſhoot themſelves into oblong ſharp Wedges, which ſtick together the Parts of all Bodies. Now in a half Years Abſence of the *Sun*, in what Quantities, and with how much firmneſs wou'd theſe Saline Bodies have form'd themſelves! Certainly nothing that moves, whether *Animate* or *Inanimate*, wou'd have been able to ſupport ſuch a cold And all this is not only demonſtrable *à priori*, but is Matter of fact, and actually happens in thoſe Places that are under the *Poles*, during a much ſhorter Abſence of this *glorious Star*. Again, in the enlightned half of the Year, we ſhou'd have had, firſt huge Deluges of melted Waters, from the preceding Snow, which likewiſe wou'd have produc'd ſuffocating Miſts; next all our Ground, wou'd have turn'd into a ſtiff ſtinking *Puddle*, (being in a manner diſſolv'd by the Force and Quantity of the

Snow Water) then wou'd *ſultry Heats* and a burning Air have gall'd us, that we ſhou'd have found reſt, neither in Houſes nor Dens; till at laſt the Heat encreaſing without Abatement, the Blood and Spirits of all the *Animals* of our *Globe*, wou'd be quite exhal'd, or they turn'd delirous by the violent Agitation of the Blood and Spirits, and then dy'd in *Convulſions*, like ſo many Puppies in the *Dog-Days*; for it were abſolutely impoſſible, that any thing that has Life ſhou'd reſiſt ſuch a Degree of Heat. It's true, there are ſome People live under the *Æquator*, yet they have but a ſcurvy time on't, tho' they are ſupply'd with conſtant Breezes, ariſing from the *Earth*'s *Rotation* about her *Axis*, and prodigious Quantities of Rain, falling by the Plenty of Vapour, rais'd by the Days Heat, and let fall by the ſupervening Cold of the Night, having as long a Night as they have a Day, which is a mighty Relief, the continued uninterrupted Action of the *Sun*, being by much a far harder part, than the Degree of the Heat at ſtated Seaſons. And as for the *Poles*, we have very certain Information, that few if any at all, inhabit near 'em. The extreme Degrees of Heat and Cold that happen there, being incompatible with an *Animal* Life. But that which makes the Caſe much worſe than in any part of our *Globe*, upon this Suppoſition, is, that the Rays of the *Sun* wou'd be both direct, and there cou'd be no Rains nor Winds becauſe it is the cooling of the Air, that is the Cauſe of both; which by no means cou'd happen in our Caſe, every ſucceeding Hour heating the Air to a greater Degree than the former. Add to all theſe, that our Seas even notwithſtanding our *Tides*, wou'd either be exhal'd, or turn'd into Deſarts of Salt, and ſo, not only our Fiſhes wou'd be deſtroy'd, but we cou'd have no freſh Waters, ſeeing we cou'd have no cool Air to ſend it down: If we had any *Plants* or *Vegetables*, they wou'd be but of one particular kind, *viz.* thoſe which require the greateſt Degrees of Heat, but it is demonſtrable we ſhou'd have Occaſion for none; for any body who underſtands the *Animal Oeconomy*, will eaſily ſee that no *Animal*, ſuch as we have on our *Globe* now, cou'd bear ſuch an exceſſive and uninterrupted Degree of Heat. Upon all which Accounts it is very plain, that the preſent *Rotation* of the *Earth*, about her *Axe*, is one of the moſt ſignal Inſtances of Wiſdom and Contrivance, that can be imagin'd.

§ XXV. Next let us combine this *Diurnal Rotation* of the *Earth*, about its own *Axe*, with the *Annual Revolution* of the ſame about the *Sun*, and the *Paralleliſm* of the *Axe*, of the *Diurnal Rotation* with itſelf: And from thence we ſhall have the beautiful Seaſons of the Year; Seed time, and Harveſt, Summer, and Winter; the comfortable Viciſſitudes of colder and warmer Periods, of Snow, and Rain, Winds and Calms, of ſhorter Days, and longer Nights, and again of longer Days, and ſhorter Nights, and of all thoſe delightful Changes, which are ſo pleaſant, comfortable, yea, and neceſſary in our preſent Circumſtances. If the *Earth* had only turn'd about her own *Axe*, once in twenty four Hours, then all our *Viciſſitudes* wou'd have been of Days, and Nights; which by no means wou'd have been ſufficient for *Vegetation*. If the *Earth* had made a *Period*, about the *Sun*, once in the Year, without any *Rotation*, we ſhou'd have had but one long Day, and another equal Night; which as I have ſhewn, wou'd not have agreed, neither with Life, nor Vegetation. If both theſe had been united without the third of the *Paralleliſm* of the *Axe* of the *Diurnal Rotation* to itſelf, we might have had Days and Nights, but our other Seaſons wou'd have been uncertain, and in ſome Places none at all; and ſo the Effect of the Annual Revolution wou'd have been deſtroy'd in ſome Meaſure. But by this wiſe Conjunction of all theſe three Modifications, we enjoy our Seaſons, and the other conſequent Changes of the Year, which are of ſo great uſe to us; for had we enjoy'd a conſtant uniform Seaſon all the Year round, ſuppoſe of Summer Weather, then our Ground had been exhauſted, and worn out by conſtant bringing forth of *Vegetables*, and wou'd have run into Weeds, and thoſe other Plants that require the leaſt rich Soil, and moſt Heat only; ſo that in a few Years the *Earth* wou'd have been reduc'd into a *Wilderneſs* of unuſeful Herbs; for toward the Production of the more uſeful Plants, there is requir'd (beſides a certain Degree of Heat and Moiſture,) a *Lixivial* and *Nitrous Salt*, which keeps the Mould looſe (for receiving the moiſt Air, and for the entry of that Heat and Moiſture.) For tho' *Salts* conſolidat Water, which conſiſts of ſolid porous Parts, whereby their Particles are ſtuck together, yet they keep the Parts of Mould or Sandy Clay (which has little or no Water) aſunder, and looſe, by the ſame very Reaſon, for their Particles not allowing them entry into themſelves, they get betwixt 'em, and firſt ſeparate their union, and then keep 'em from coming together; and perhaps both forward the Motion of the Liquors in the *Vegetable* Channels (which are certainly endow'd with ſome Degree of *Elaſticity*, and ſo capable of being ſtimulated, as is evident in younger Twigs and Branches, as well as *Animal* ones) and endows the Juices with the Qualities the *Plant* requires. Now theſe are either quite exhauſted, or deſtroy'd, by conſtant Growth and *Vegetation.* We ſee the beſt Ground wears out in a few Years, and turns into wild uſeleſs Weeds; and all the Materials for enriching Ground, are gathered from Places, debar'd from the Action of the *Sun*, and the Expences of *Vegetation*, but expoſs'd to the Air, and Weather, whereby they are impregnated with this *Nitrous Salt*: Such are old Turf, new Mould, the Dung, and Excrements of *Animals*; or thoſe things which abound with *Lixivial Salts*; ſuch are burnt Wood, burnt Turf, Stubble, and the like. Now all theſe, wou'd by a ſhort Time's uninterrupted *Vegetation* have been quite ſpent. Add to theſe, that in a perpetual *Summer*, there would not fall ſufficient Quantities of Rain, to moiſten and ſoften the Mould, to that Degree that is neceſſary for conſtant *Vegetation*; for we find there is more than twice or thrice as much Rain falls in the *Winter* ſix Months, from *September* to *April*, than in the *Summer* ſix Months; and yet all this is but ſufficient for one ſix Months *Vegetation*. Moreover, even the *Animals* themſelves, cou'd not conveniently bear a perpetual *Summer*; for we find now, that the cold of the *Winter*, by ſtoping the Pores of the ſenſible Perſpiration, keeps the Warmth more within, whereby there is a greater Quantity of Spirits generated, the Blood is leſs rarify'd, the natural Functions, are more ſtrong, and perform'd with more Vigour, the Digeſtion is better, the ſenſible Excretions more natural, and leſs violent, and the Crudities of the preceding *Summer* are ſettled and digeſted, I mean, in healthful and ſound *Animals* (for the Caſe is quite otherwiſe in *Valetudinary ones*, as of neceſſity it muſt be) and in a moderate and not over tedious *Winter*; wheras in *Summer* the Blood is more rarify'd, the Spirits more exhauſted, the *ſenſible Perſpirations* more violent, and leſs natural, the Digeſtion worſe, and all the Concoctions leſs thoroughly perform'd. So that it is evident we cou'd bear neither of theſe States perpetually, the Change of the *one* being abſolutely neceſſary to qualify the Errours and Extreams of the *other*. If we had a perpetual *Summer*, we ſhou'd be reduc'd to meer *Skeletons*; if a perpetual *Winter*, we ſhou'd turn Dull, unactive *Drones*. Now perhaps againſt all theſe it may be objected, that there are rational Creatures, who inhabit this *Globe* of ours, who are perpetually in both theſe Extreams, and yet are found to be not at all diſpos'd, as I pretend they wou'd be. To this I anſwer, that tho' as to the Preſence or Abſence of the *Sun*, they may be much the ſame as I ſuppoſe, yet, there are other concurring Circumſtances, which ariſe from the *Viciſſitudes* of the Seaſons in the other Parts of the *Globe*, which alters the Caſe quite; for there are conſtant Seaſons of Rain, in the more *Southern* Countries, which fall for ſome conſiderable time, that both hinders the perpetual *Vegetation*, ſoftens the Mould, and fattens it for the next Crop; there are Clouds of Snow, and Rain, impregnated with theſe *nitrous Salts*, which are driven (by the Force of the Winds) from colder into theſe hotter Countries; and there falling, do enrich the Ground. Beſides that, even the Clouds, rais'd from theſe hotter Countries themſelves, when deſtill'd into Rain, are ſufficient for this end; for as I have ſaid before, the Air every where is full of ſuch *Salts*, as is known by Experiment. Let any one conſult *Varenius*, and he will be ſatisfied that theſe Southern Countries have *Winters*, though not of Snow, yet what is abundantly ſufficient to ſtop the perpetual *Vegetation*, to moiſten, ſoften and fatten the Mould, and to cool the Blood, and other Fluids of the *Animals*. Now the Principal thing that makes this *Poetical* ſtate of a Perpetual *Summer*, unfit for the preſent Conſtitution of the *Animals* and *Vegetables*, is, that in ſuch a ſtate (either ariſing from only a *Diurnal Rotation*, without an *Annual*, or an *Annual* without a *Diurnal*) there wou'd not be that variety of Rains, and cool Breezes, nor conſtant, and Trade-winds, nor overflowing Rivers, and ſuch like Circumſtances, which are the Effect of this Combining theſe two Motions together. I need not ſhew the Inconveniences of a perpetual *Winter*, every Body is ſufficiently ſenſible, that upon ſuch a Suppoſition, we ſhou'd have neither *Vegetable* nor *Animal* in a very ſhort Time; eſpecially of any conſiderable uſe, or value, ſuch as require a *Summer*'s Heat, for their Growth; and as for *Spring* and *Autumn*, they are not ſo much diſtinct Seaſons from the two former, as Gentle *Gradations* and eaſie Steps, whereby the one ſlides into the other, through the intermediate Degrees. From all which it is evident, how wiſely theſe three ſo different Modifications, have been link'd together, for the Benefit of the Inhabitants of this *Globe*; for by theſe, we have ſufficient Heat in *Summer*, to ripen the Fruits that are the product of every reſpective *Climat*; and we are furniſh'd with Reaſon, and made capable of Induſtry, to transfer the Products of one Country to another; we have Rain, and cooling Breezes in the *Winter*, of thoſe Countries, where Heat is not wanting, to cool, ſoften and enrich the Mould, and to ſtop conſtant *Vegetation*; and we have Froſt and Snow in others, where the Heat is not to ſpare, to lock up the Mould from being waſh'd away, and keep in either the natural, or adventitious Heats, till the time that all Circumſtances concur, to have the product of the Ground brought to its *Vegetation*.

§ XXVI. Come we now to conſider the *Obliquity* of the Plane of the *Ecliptick* to that of the *Æquator*, or of the *Axe* of the *Diurnal Rotation*, to the Plane of the *Annual Orbit* of the *Earth*, which makes an *Angle* of 66 ½ Degrees. I have already ſhewn, that if the *Equator* and *Ecliptick* had coincided, it wou'd have rendred the *Annual Revolution* of the *Earth* quite uſeleſs; for if the *Earth* had mov'd about its own *Axe*, and this *Axe* had been at right *Angles* with the Plane of the *Ecliptick*, the ſame Appearances as to the *Viciſſitudes* of Day and Night, had happen'd; whether the *Earth* had mov'd round the *Sun*, or not; and the Alterations of Seaſons, and all the Conſequences thereon depending, had not been at all; and what a hinderance this wou'd have been to *Life* and *Vegetation*, I have already ſhewn: Beſides that in the *Torrid Zone*, the Heat wou'd have been intolerable, and not to have been endured; and in the *frigid Zones*, the Cold wou'd have deſtroy'd both *Animals* and *Vegetables*; and even in the *Temperat Climats*, the one half of e'm wou'd have made but a very comfortleſs Habitation, for ſuch Creatures as we now are; ſo that but only the other half, wou'd have been any ways, a tolerable Seat for rational Creatures, and five ſixths at leaſt of the whole Globe, wou'd have been rendred uſeleſs. But *God* who is wiſer than Man, has contriv'd the Matter much better; for by this preſent *Obliquity* of the *Ecliptick* to the *Equator*, we reap one very conſiderable Advantage, which is taken notice of by my very learn'd and ingenious Friend Mr. *John Keill*, and that is, that we beyond the forty fifth Degree of *Latitude*, and who conſequently have the greateſt need of the *Sun*'s Heat, have more of it, take the whole Year about, than if the *Sun* had mov'd continually in the *Equator*; and they that live in the *Torrid Zone*, and the adjacent Places, even to the *Latitude* of forty five Degrees, who are rather too much expoſed to the Heat of the *Sun*, than too little, have by theſe Means, leſs of his Heat, than they wou'd have had, had the *Earth* obſerv'd a right Poſition;

ſition. Thoſe who deſire to ſee the Demonſtration of this, may conſult Mr. *Keill*'s Examination of Dr. *Burnet*'s *Theory* of the *Earth* pag. 71. *&* *ſeq.* To theſe add, that ſince this *Globe* of ours, has been deſign'd for a Habitation of rational and irrational Creatures, of various *Tempers*, *Conſtitutions* and *Diſpoſitions*, and for *Vegetables* of different *Natures* and *Virtues*, requiring different Degrees of Heat, and Nouriſhment, to ripen, and bring 'em to Perfection, (to ſhew the *manifold* Wiſdom of the *Author* of *Nature* in the Variety of every thing.) And ſince we find the preſent Heat of the *Torrid Zones*, very well fitted for all the Kinds of *Animals* and *Vegetables* that inhabit and grow there, the Cold of the *Frigid Zones*, very tolelerable to the *Inhabitants* and *Productions* of theſe Places, and the *Temper* of the intermediate ones, ſuited to theirs; thoſe *Animals* that cannot tranſport themſelves, and the *Vegetables* that require a greater Degree of Heat, not having too much, and the like *Animals* and *Vegetables*, that can ſuffer cold, not having too little Heat, and the rational Creatures being endow'd with Reaſon and Means, to tranſport themſelves where they live moſt at eaſe. And ſince it was impoſſible to have accommodated, all theſe ſo various and different *Animals* and *Vegetables* in a place of an equable and uniform, (or in one, and in the ſame) *Climate*, it's evident that the preſent Situation of the *Axe* of the *Earth*, to the Plane of the *Ecliptick*, is the beſt (of that infinite Variety poſſible) that cou'd be, for our preſent Circumſtances; for by any other very conſiderable *Alteration*, all or moſt of the mention'd Advantages would be loſt. For all which Reaſons we can never ſufficiently admire, the *Wiſdom* of the *Author* of *Nature*, who has provided ſo liberally, and prudently for his Creatures.

§ XXVII. The ſame divine Wiſdom, is conſpicuous, in the Situation of the *Earth* in reſpect of the *Sun*; for had the Diſtance between the *Earth* and the *Sun*, been the ſame with the Diſtance between

Mercury and the *Sun*, *i. e.* were we brought three times nearer the *Sun* than we are, or the *Sun* brought three times nearer us than he is, our Ground in Winter, wou'd have been hotter than red hot Iron, and what a Condition we ſhou'd have been in then, we may eaſily gueſs. On the other Hand, had the *Sun* been remov'd from us, or we from the *Sun*, to the Diſtance *Jupiter* or *Saturn* are remov'd, our hotteſt *Summer Day* had not afforded ſo much Heat, as thoſe that now live under the very *Polar Star* (if any ſuch there be) of our Globe feel in the midſt of Winter. Are not we then very wiſely provided for, who are put in ſuch a Mediocrity, between theſe two extream Diſtances, that neither our Heat nor Cold is ſo violent, but that we may either endure 'em, or with a little Induſtry fence our ſelves againſt their Injuries? Again, as to the *Figure* of our *Earth*, tho' it be the neceſſary Reſult of the *Earth*'s *Rotation* about its own *Axe*, and the Fluidity of the ſuperficial Parts of the *Earth*, at the Commencement of this Rotation; yet it is very convenient for us. By the *Earth*'s Motion about its *Axe*, the Parts endeavour to recede from the ſame *Axe* as much as they poſſibly can, by a *centrifugal* Force, ariſing from the circular Motion; and therefore, if the Matter of any of the Heavenly Bodies, was fluid, at the Commencement of this circular Motion, it wou'd neceſſarily have riſen from the *Poles*, and accumulated at the *Equator*, and ſo induced a *ſpheroidical* Figure on the *Planets* Body, generated by the *Circumvolution* of an *Ellipſe* about its leſſer *Diameter*. Now ſince it is evident to our ſight, aſſiſted with a good *Teleſcope*, particularly, in *Jupiter*, that the *Diameter* at the *Equator* is longer, than that at the *Poles*, and ſince Mr. *Newton* has demonſtrated that *Earth* is at leaſt ſeventeen Miles higher at the *Equator* than at the *Poles*, its plain that at the Commencement of the diurnal Rotation, the Surface of the *Planets* has been covered with a Fluid; which gives an Account why at every forty or fifty fathoms, below the Surface of our *Earth*,

Earth, we never miſs of Water. It is likewiſe evident from this Figure of the Body of the *Planets*, that the Surface of the *temperate Climates* is larger than it wou'd have been, had the *Globe* of our *Earth*, or of the *Planets*, been either *ſpherical* or *oblongly ſpheroidical*; ſo that the Advantage of this Figure is very conſiderable, the Surfaces of the *Polar Regions*, which by reaſon of the oblique Incidence of the Rays of the *Sun* upon them, are colder, and leſs convenient for the Habitation of *Animals*, and the Production of the nobler Sort of *Vegetables*, are hereby conſiderably leſſened, and the Surfaces or Space about the *temperate Zones*, which are moſt comfortable and uſeful, are thereby conſiderably enlarged. The ſame Figure obtains not only in the *Earth*, and the reſt of the *Planets*, and their *Satellits* but likewiſe in the *Sun*, and univerſally in every fluid Body revolving about an *Axe*.

§ XXVIII. Having ſhewn ſome of the Advantages ariſing from the ſeveral Motions of the *Earth*, and the Combination of theſe, which are common to the other *Planets*, I come now briefly to conſider, thoſe that poſſibly may be more particularly belonging to our *Globe*, and are not the immediate Conſequence of its Motions; and the firſt in order is our *Atmoſphere*, of ſuch Neceſſity toward the ſubſiſtence of *Animals*, and the growth of *Vegetables*, that neither, cou'd be any conſiderable time without it. This *Atmoſphere* is a thin *Elaſtick* Fluid, intermixt with Particles of different Natures, ſurrounding our *Globe* to the heighth, of about forty or forty five Miles. The Nature and Properties of this Fluid, I have in ſome manner ſhewn already. But ſome of it's uſes I ſhall now point out, and firſt as to *Vegetation*, Dr. *Grew* and *Malpighi* have ſhewn that it is a principal concurrent therein, it being more eaſily rarified, and heated by the *Action* of the *Sun*, than other more compact, heavy, and leſs *ſpringy* Fluids, is fitter to promote the Aſcent of the Juices in the ſlender Channels of *Vegetables*, and there being no Fluid without a conſiderable Portion thereof, lodged up and down among it's Parts, the firſt Impulſe of the Juices upwards, does thence ariſe. Moreover, as to *Animals* it is well known, that they cou'd live but a few Minutes without this *Elaſtick* Fluid, and probably that which ſo ſuddenly kills thunder-ſtruck *Animals*, is the quick and violent Rarefaction of the Air about them; for the *Lungs* of all ſuch upon opening, are found quite deſtitute of Air, and the ſides of their *Veſicles* quite clap'd together. It's certain, that the Blood is ſent from the right Ventricle of the Heart to the *Lungs*, and if the Veſicles thereof be not diſtended or blown up, by the Air, the *Circulation* muſt ſtop there, and the *Animal* periſh; and both for the Comminution of the Particles of the Blood, that they may more eaſily paſs through the *Capillary* and terminating Veſſels, and for the Propagation thereof in the wider ones, there is neceſſarily requir'd a Fluid of a determinate Gravity, and *Elaſticity*. We have as great Difficulty of breathing, in a thin as in a thick Air; and ev'n in *Fiſhes*, where the Water in ſome meaſure ſupplys the want of Air, yet if you draw out all the Bubbles of Air, which are always found in Water, they will languiſh and dye; ſo that ev'n to them, a certain Portion of this *Elaſtick* Fluid, is neceſſary. Now how well is this Fluid fitted for the generality of the Inhabitants of this *Globe?* it being neither too heavy, nor too light, neither too much, nor too little *elaſtick*, for the uſes of Reſpiration. Another Advantage we reap by our *Atmoſphere*, is, that by it our *Clouds* and *Vapours* are ſupported, without which we ſhou'd neither have freſh Water, nor Snow, nor Rain, nor any of thoſe things, which moiſten and enrich our Soil, and make it fit for *Vegetation*. For tho' it be the *Sun* that rarifies the Water, and makes it take its firſt flight in *Vapours*, and *Steams*; yet its by the *Atmoſphere*, it's Progreſs is continued to the upper Regions, and ſupported when it is there, to be afterwards form'd into Snow, or Hail, or Rain, or carried into other Regions, whoſe Soil does want it more. Every Body knows, that if there were no *Atmoſphere*, but a perfect *Void*, around the *Earth*, the Action of the *Sun*, wou'd not be able to raiſe the *Vapours* above a few feet, from its Surface; and that its only the *Atmoſphere*'s being *ſpecifically* heavier, than theſe *Vapours*, that buoys 'em up in the Air, by its greater Tendency toward the Center. Now then, if there were no *Atmoſphere*, the *Vapours* cou'd riſe to no ſufficient heighth, and ſo cou'd never be cool'd ſufficiently, ſo as to be form'd into Snow, or Rain; for at a ſmall diſtance from the *Earth*'s Surface, the reflected Rays of the *Sun*, make the Places ſo warm, that no *Vapour* cou'd be turn'd into Snow, or Rain, there; for it's the Coldneſs of the upper Regions, (being deſtitute of theſe reflected Rays) and the length of of their Deſcent, that forms theſe *Clouds* and *Vapours* into Snow, and Rain, whenever the ſupporting *Atmoſphere* becomes lighter, than theſe accumulated *Vapours*, they fall down with the Temper of Heat or Cold, they had in the *upper Regions*, and ſo become Snow, or Rain accordingly. So that its plain, it's our *Atmoſphere* that is one of the principal Means of our Dews, and Rains, and all the Bleſſings, that follow upon theſe. A third Advantage of our *Atmoſphere* is, our *Breezes* and our *Winds*, which carry our Ships upon the Sea, and purifie our Air, from noxious Steams, which (with the Concurrence of the *Sun*) melt our Snows, and dry our Ground when over-moiſtned; and ſerve for ſo many other Purpoſes, for the Accommodation of Humane Life. *Wind* is nothing but a violent Motion of the Air, produc'd principally by its Rarefaction, more in one Place, than another, by the *Sun*'s Beams, the *Attractions* of the *Moon*, and the Combinations of the *Earth*'s Motions. Without our *Atmoſphere*, we ſhou'd have no more *Wind* above, than under Ground, and ſo be depriv'd of all the Benefits ariſing thence. Laſtly, Our *Atmoſphere* is the Vehicle and *Medium* of ſound, that Senſe which moſtly diſtinguiſhes us from *Fiſhes*, and the inferior ſort of *Inſects*. *Sound* is nothing but a *Modulation* or *Percuſſion* of the Air, communicated by an impulſe, from the vibrating ſonorous Body, and propagated in *Undulations*, through the Fluid of the *Atmoſphere*, ev'ry way round. Without our Air we ſhou'd not be able to hear the Report of a thouſand Pieces of Ordnance diſcharg'd at the ſmalleſt Diſtance; we ſhou'd have no ſuch thing as Languages or *Muſick*, and what a comfortleſs ſtate this wou'd be, I leave the Reader to judge. From all which it's very plain that there was *Counſel* and *Deſign* in the Contrivance and Production of our *Atmoſphere*.

§ XXIX. The next thing in Order to be conſidered is, our *Mountains*, without which it were almoſt impoſſible for *Animals* to ſubſiſt, or *Vegetables* to grow, they being one of the principal concurrent Cauſes toward the Production of our freſh-water Rivers. It has been ſhewn from Calculation, by ſeveral Perſons, and particularly the ingenious Profeſſor of Geometry at *Oxford*, Mr. *Ed. Halley*, that the *Sun* raiſes Vapours from the Surface of the Sea, in a Year, ſufficient to ſupply all the Rivers with freſh Water for that time. Now theſe Vapours being rais'd (the *Sun* acting upon the Surface of the Sea, as a Fire under an *Alembick*, by rarifying the ſame, it makes the lighteſt, *i. e.* the freſheſt Portions thereof, to riſe firſt; and it rarifies the Water by the Inſinuation of its active Particles among the porous Parts thereof, whereby they are put in a violent Motion innumerable different ways, and ſo are expanded into little Bubbles of larger Dimenſions than they formerly had, and by that means become *ſpecifically* lighter, and ſo are buoy'd up by the weightier *Atmoſphere*) in ſuch Quantities, as is ſufficient to make Streams of Vapours, which reſting in thoſe Places, where the Air is of equal Gravity with them, are carried up and down the *Atmoſphere*, by the Courſe of that Air, till they at laſt hit againſt the ſides of the more eminent and *Mountainous* Places, of the *Globe*, and by this Concuſſion are condenſed, and thus become heavier than the Air they ſwom in, and ſo gleet down the rocky Caverns of theſe *Mountains*, whoſe inner Parts being hollow, and ſtony, afford them a *Baſon*, till they are accumulated in ſufficient Quantities to break out at the firſt *Crany*; whence they deſcend into the Plains, and ſeveral of them uniting, form Rivulets, and many of theſe Rivers; ſo that it is evident the great Benefit of theſe Eminences is not, that by the Shock theſe Vapours get in their Courſe from them, they are condens'd, ſo as to be precipitated thereby through the Chinks of the Rocks, but that afterwards in their Bowels they are preſerv'd, till they be of ſufficient quantity to form Rivulets, and then Rivers; for doubtleſs our Vapours wou'd fall in Rain, and Dew, tho' there were no *Mountains*, but then they wou'd fall equally, over conſiderable Places of the *Globe* at once, and ſo wou'd be ſuck'd up in the Ground, or make an *univerſal Puddle*; whereas by theſe *Mountains*, they are perpetually almoſt, (at leaſt a Nights) pouring down in ſome particular Places, and there treaſuring up, for a conſtant Supply to the Rivers. Another very conſiderable uſe of theſe *Hills*, and *Eminences*, is the Determination of theſe Rivers; for tho' there had been Rivers without Mountains, (which is hardly poſſible) yet in that caſe the Rivers cou'd only have run in a ſtraight Line, if they had run at all; whereas, by theſe *Eminences*, plac'd up and down the *Globe*, the Rivers make innumerable beautiful turnings and windings, whereby they enrich, fatten, and water the Soil of ſeveral different Countries in one Courſe, make the Tranſportations and Carriage over Lands more eaſie and manageable, and at laſt diſembogue in ſeveral Mouths into the *Sea*; where, by the aſſiſtance of the *Tides*, they from Harbours and Ports, for the convenience of *Shiping* and *Navigation.* All theſe Advantages we have by our *Mountains*; for tho' from other Cauſes, we might poſſibly be ſupply'd with freſh Water *Springs*, (tho' Nature ſeldom is *Luxuriant* in diverſity of Cauſes) yet without our *Mountains* we cou'd never have Rivers, nor cou'd theſe Rivers have ſuch delightful turnings, nor thoſe uſeful falls, which gives them an impetuoſity that may be improv'd to ſo many delightful as well as profitable Uſes. Thus we ſee of what Advantage theſe unſightly Mol'es (as ſome thought them) are to the Accommodations and even Neceſſities of living.

§ XXX. Next come our Fluids to be conſidered, without which we cou'd never have been, ſeeing they are a very *eſſential* part of us; that which I ſhall principally take notice of, is, 1. The fewneſs of the *original* and *primary* Fluids, in reſpect of that vaſt Number of compounded ones, which are indeed numberleſs.

The *primary* ones are only four, *viz.* *Air*, *Water*, *Mercury* and *Light*; three of which are but ſeldom much compounded with others, ſo that it is Water alone, or *Lymph*, that is the *Baſis* of all our Mixtures, and it is the parts of ſolid Bodies floating in this Fluid, that produces all our delightful and uſeful varieties of Liquors; ſo frugal is Nature in *Principles*, and ſo fruitful and various in Effects and Compoſitions. 2. The great Difference between the *ſpecifick* Gravities of our Fluids, *Mercury* being about 8000 times heavier than *Air*. Now not to mention the many uſes of this laſt Fluid in Artificers Works, had *Air* been as heavy as *Mercury*, it had been altogether uſeleſs in reſpiration; on the contrary, it had choaked us immediately; and had there not been a Fluid of the ſame weight with *Mercury*, *i. e.* a collection of exceeding ſmall, vaſtly heavy *Spherules*, in the preſent Circumſtances of Mankind, I do not know what a great part of the World would have done. For the Lewdneſs and Debauchery of Mankind, has brought a great many Diſeaſes to that degree of Malignity, that I ſcarce ſee how a thorough Cure cou'd be made of 'em, without this Fluid; for it's certain, wherever any Diſtemper ariſes from an obſtruction of the Blood Veſſels, wherein the *Globules* themſelves, and not the *Serous* part is principally concern'd, that this Fluid, if not abſolutely neceſſary, is extreamly beneficial; for nothing has ſufficient force to take away this obſtruction, and to ſeparate theſe *Globules* from one another, in the extreme *capillary* Veſſels, but a little weighty *Sphere*, ſuch as the Particles of *Mercury* certainly are. Now by this difference of the *Specifick* Gravity of the Fluids, a Remedy is provided for all theſe Maladies, which I am ſatisfied are more than two or three. But that which is moſt wonderful in theſe Fluids, is, 3. The univerſal condition of the direction of their *Preſſure* upon the ſides of the containing Veſſel; for in all Fluids of whatſoever kind or nature, this *Preſſure* is communicated in Lines *perpen-*

dicular to the ſides of the containing Veſſel. Now this Property of Fluids, which is ſo beautiful and uniform, is the neceſſary Conſequence of the *Sphericity* of their conſtituent Particles; for ſince by the third Law of Nature, *Reaction* or *Repulſe* is always equal and contrary to Impulſe or Action, in the ſame Direction, conſequently the ſides of the containing Veſſel preſſes the contain'd Fluid, as much as the contain'd Fluid preſſes the ſides of the containing Veſſel; and this *preſſure* of the ſides of the containing Veſſel, is directed in the ſame right Line with that of the contain'd Fluid, but is contrary to it. Now ſeeing a *right Plane*, can only touch a *Sphere*, in a point, and can preſs it in a direction through that point of Contact; if this Direction through the point of *Contact*, do not likewiſe paſs through the Center of the *Sphere*, the *Sphere* will neceſſarily revolve upon the *Plane* till the Direction of its *preſſure*, from the point of *Contact* paſs through the Center of the *Sphere*; juſt ſo likewiſe, if a *Plane* preſs two *Spheres*, in the ſame Direction, the Line of this Direction will neceſſarily paſs through both their Centers. And ſo if there be any number of *Spheres* whatever, preſs'd by a *Plane* in the ſame Direction, the Line of this Direction will neceſſarily paſs through all their Centers. But a Line through the Center of a Sphere from the point of Contact, is *perpendicular* to the *Tangent Plane*; and ſince this is the Direction of the *preſſure* of the *Plane* upon the *Spheres*, it is alſo the Direction of the *preſſure* of the *Spheres* upon the *Plane*. Since alſo the Particles of Fluids, are *Spherical*, or nearly approaching thereto, and ſince they are ſuppos'd exceeding ſmall, as alſo ſince *curve* ſurfaces are compounded of an infinite Number of little plain ſurfaces, it is univerſally true, that all Fluids of what nature ſoever, preſs the ſides of the containing Veſſels in a Direction *perpendicular* thereto. And on the other hand, ſince by *demonſtration*, it is true, that Fluids do preſs the ſides of the containing Veſſels, in a Direction *perpendicular*

dicular thereto, it's certain that the Particles of all Fluids are *Spherical*, or nearly approaching thereto; ſo that this is now no more *Hypotheſis* but *Demonſtration.* Now cou'd any thing but the Fingers, and *Almighty Power* of God, have rounded thoſe infinite numbers of ſmall Particles; whereof Fluids conſiſt? or cou'd any thing but his *Wiſdom*, have aſſign'd them their true dimenſions, their exact weights and requir'd Solidities? We ſhall allow him to continue in his infidelity who can demonſtrate by what Laws of *Mechaniſm*, all the Particles of Water were turn'd of the ſame *Diameter*, Solidity and Weight, and thoſe of Air, *Mercury* and *Light*, turn'd all of different *Diameters*, Solidities and Weights from one another; but all of the ſame *Diameters*, Solidities and Weights among 'emſelves.

§ XXXI. What a noble repreſentation of the Divine Wiſdom does our Fluid of *Light* afford us! how wonderfully are its parts fram'd! and with what a prodigious *velocity* are they ſent from the Body of the *Sun!* its Subtility is almoſt beyond imagination, no Pore ſo ſmall as to exclude it; no Stream of it ſo great, but may be congregated into a ſingle Point; no Surface ſo finely poliſhed, as not to ſcatter almoſt one half of it; its Rays traverſe through one another, millions of different ways, without interfering ev'n in the ſtraiteſt Paſſages; in one Word, we are not able to comprehend nor imagine a Number ſufficiently ſmall, to expreſs its ſubtility; in every Pulſe of an *Artery*, it runs ſome *hundred and thirty thouſand Miles*; what an amazing, and unconceivable *velocity*, muſt this be! nothing but the action of the Mind, can any ways repreſent it: And then what a beautiful *Idea* of this Fluid, do Mr. *Newton's later Diſcoveries* preſent us with, ev'ry Ray is endow'd with its own *Colour*, and its different degree of *Refrangibility* and *Reflexibility*. One Ray is *Violet*, another *Indigo*, a third *Blew*, a fourth *Green*, a fifth *Yellow*, a ſixth *Orange*, and the laſt *Red*. And theſe are the *primary* and *original*

ginal Colours, and from the mixture of theſe, all the intermediate ones proceed, and *White* from an equable mixture of the whole; *Black* on the contrary, from the ſmall quantity of any of them being reflected; or, all of them in a great meaſure being ſuffocated. So that now it is not Bodies that are coloured, but the *Light* that falls upon them, and their Colours ariſe from their *Aptitude*, to reflect Rays of one Colour, and tranſmit all thoſe of another. Their prominent little Parts, upon their Surfaces, according to their different Degrees of *denſity* and *thinneſs*, are apt to reflect back upon our *Organs*, Rays of one Colour, and of one degree of *Refrangibility* and *Reflexibility*, and to let others paſs through their Pores; and this one Colour too, is leſs or more intenſe, according as their prominent parts are of different *denſities*, or are thicker or thinner. For the firſt degrees of *Intenſeneſs*, in all the *primary* Colours, ſeem to ariſe from ſome determin'd degrees of *denſity* and *thinneſs*; and the ſubſequent degrees from, the other different degrees of denſity or thickneſs or thinneſs, of the prominent little parts, of the Surfaces of Bodies. *Light* acts upon Bodies by heating, diſſolving, and puting their parts in a *vibrating* Motion; as alſo Bodies act upon *Light*, in drawing its parts to them, and that in Lines *perpendicular* to their Surfaces: All the differently *reflexible Light*, obſerves this one Law, that all the different *Angles* of *Incidences* are reſpectively equal to the *Angles* of *Reflexion*; and all the differently *Refrangible* Rays of *Light*, obſerve one Law likewiſe, *viz.* that in all the *obliquities* of the ſame Ray, to the Plane of *Incidence*, the *Sines* of the *Angles* of *Incidence*, are to the *Sines* of the *Angles* of *Refraction* in a conſtant *ratio*; and both theſe Properties proceed from one, and the ſame Principle, acting in different Circumſtances, *viz.* that Bodies attract *Light* in *Lines perpendicular* to their Surfaces, and that this attraction is equal in all the *Incidences*, and *Refractions* at equal Diſtances from the ſame *Plane*, and the *reflected* Rays are turn'd back before they arrive at the *reflecting* Plane: For if the *reflecting* Plane, have ſuch a force of *attraction*, that before the Ray arrives at it, it has already made the *Sine* of the *Angle* of *Incidence*, equal to the *Radius*, the Ray muſt reflect, and not fall upon the reflecting Plane at all; if a leſſer degree of *attraction*, then muſt it enter the Body of the Plane, and proceed in the Line, that its direct *impulſe*, together with the degree of *attraction* in the *refracting* Body, neceſſarily generates. And as there are different degrees of *Attraction* in Bodies, which produce their different degrees of *Elaſticity* and *Cohesion*, ſo there muſt be different degrees of *attraction* in *Mediums*, ſuppos'd, to account for their different *Powers*, in bringing the *refracted* Rays nearer to or farther from, the *perpendicular*; for it's well known, all *Mediums* have not the ſame *refractive* Virtue. Now what a beautiful, uniform, and ſimple *Theory* of *Light*, is here? this is ſo very like the *frugal ſimplicity*, and yet the *ma-*

nifold variety of Nature, that one would be almoſt tempted to believe it true, were there no *Demonſtration* and Experiment to confirm the truth of it. I might likewiſe ſhew here the Art and Contrivance of Nature, in the production of the *Coheſion* of Bodies. But having been pretty copious on this Subject already, I ſhall only ſuggeſt one very remarkable Inſtance of the wonderful Contrivance and Wiſdom of Nature, in the *propagation* of *Light*, *viz.* that a Ray of *Light*, in paſſing from a luminous Point, through two differently *refracting Mediums*, to illuminate a given Point; ſpends the leaſt time (the refracting Powers of the ſeveral *Mediums* conſidered) poſſible, and conſequently when the Ray paſſes, but through one and the ſame *Medium*, *i. e.* when a Ray paſſes from a luminous Point, to reflect upon a given Point, it takes the ſhorteſt way poſſible. This the *Geometers* have demonſtrated, and particularly, Mr. *Hugens* in his Treatiſe of *Light*, very elegantly *Page* 40 *and* 41. Now I appeal to the Reader, how *incredulous* ſoever, if this be not an Inſtance of *Counſel* and *Deſign*, is not this like the Methods of *Prudence* and *Wiſdom*, which will not ſpend more time on a thing, than juſt what is neceſſary to do the Buſineſs; which will not go about, but take the ſhorteſt Courſe poſſible, that will bring it to the Place deſign'd? He that can reſiſt ſuch pregnant and powerful Inſtances of Divine Wiſdom, will never be convinc'd.

§ XXXII. I ſhou'd next proceed, to ſhew the wonders in the *Bowels* of our *Earth*, but our Diſcoveries are ſo few, and our accounts of this matter, ſo lame, that nothing certain can be determin'd about theſe *Inner Regions*. Some have concluded that there muſt of Neceſſity be a Central heat, becauſe they ſaw that Springs run faſter in Froſt and Snow, than in hot Weather, but that might proceed from ſome of the other more narrow *outlets* of this *Baſon*'s being ſtopt, by the Froſt; and the *Vapours* that the *Sun* raiſes thence, being kept in. Others have thought that within this outer Cruſt of *Earth*, there muſt be a *Diſcontinuity*, for ſome conſiderable diſtance, quite round, and that there was ſucceeding this, a large *Sphere*, moving after a certain manner, to account for the *variation* of the *Magnet*; but I am of Opinion the Cauſes of this *variation* is to be ſought in the *Magnet* it ſelf, and not in ſo remote and ſo far fetch'd a Cauſe; for it ſeems pretty odd, that a *Sphere* ſhou'd be made, to whirl within the *Bowels* of the *Earth*, to make a *Peeble* turn this or the other way above Ground. If the *Earth* were an univerſal *Magnet* (as it's commonly but erroneouſly believ'd) then the parts might follow the Nature of the whole. But tho' it attracts Bodies, as well as the *Loadſtone* does, yet it's after another manner, and from a different Law. One might as probably expect a different turn and figure of internal *Orbs*, to account for the Effects and Vertues of ſeveral others of the *Metals*, *Minerals* and *various Foſſils*, and of many other *Electrick* Bodies, different from the *Loadſtone*, as of their Brother the *Magnet*. I believe an *Hypotheſis* may be form'd, whereupon by the figure and ſize of its parts in regard of Bodies attracted, this and the *variation* of its direction might be accounted for; but this is not a proper Place for theſe things. As for the analogy between theſe internal *Orbs*, and that of the *Annulus* of *Saturn*, I cannot think it holds, the one being exteriour the other interiour; the one a whole *Sphere*, the other a *Ring* only: Neither can I think that this *Annulus* can be ſome remains of the Ruins of a Cruſt, that is fall'n in upon the Body of the *Planet*, becauſe this *Ring* appears to be regular and uniform, of an equal breadth quite round, and at an equal diſtance from the Body of the *Planet*; beſides, it is ſcarcely probable that theſe *Planets*, which like ours, may be deſign'd for the Habitation of ſome ſort of *Animals*, ſhou'd be ſo ruinous as this Suppoſition wou'd make that *Planet* to be. Laſtly, all theſe *Hypotheſes* have not that ſimplicity, and artfulneſs, that the Works of Nature and

Truth carry along with them. If it be true that all the Bodies of the Univerſe *attract* one another, then it's very plain that when ever a leſſer Body (however figur'd) attends the Motions of, and revolves with a greater, that that leſſer Body is deſign'd by it's *attraction*, to produce ſome effect, that is the Conſequent of this *Attraction*. Thus it's plain, our *Moon* was deſign'd to raiſe our *Tides*, and regular Winds, and to diſturb the Motions of our *Earth*, for Purpoſes that poſſibly we may, or may never, come to diſcover; and ſo the *Satellits* of *Jupiter* and *Saturn*, were deſign'd to attract, the Fluids, or diſorder the Motions of their reſpective *Planets*; and I have ſuggeſted before, that the Multitude of the *Satellits* of theſe *Planets* may ſerve in their vaſt diſtance from the *Sun*, to hinder their Fluids (by frequent and various Diſturbance) from freezing; and the greater number of the *Satellits* of *Saturn*, than *Jupiter*, ſeems to favour this Conjecture. Now this *Annulus* may poſſibly ſerve ſome ſuch purpoſe as this, ſince it moves differently from the Body it ſelf. But all theſe are but Conjectures on both ſides; and as ſuch I leave 'em. It's certain that *Earthquakes*, and *Vulcano's*, proceed from ſome Motion and Mixture of different Particles within the Body of the *Earth*; it is likewiſe certain that its *Strata*, are not of ſuch Gravities as a regular ſubſidence according to the Laws of Gravitation of Bodies, wou'd require; which ſhews it has not been compounded by theſe Laws. It's likewiſe certain, that we have freſh Water at any conſiderable depth, in moſt Places diſtant from the *Sea*; we have from its *Bowels*, all our *Metals* and *Minerals*, with all their Varieties, which is of ſo much uſe, for the Accommodations of *Life*, and the ſubſervience of *Medicine*; from the depths of the *Sea*, and the *Bowels* of the *Earth*, we have all our natural *Salts*, which do us ſo great and manifold Services. If any one had but occaſion, to look over, the variety, beautiful Figures, and Colours, of *Shells*, *Petrifactions*, *Ores*, *Minerals*, and *Stones*, which *Induſtry* has collected, he cou'd not but admire the *manifold Wiſdom* of the Author of Nature. This were a very large and copious Field, and wou'd afford very *demonſtrative* Inſtances of *Counſel* and *Contrivance*. But I have ſo many other things to ſuggeſt on the Head I am about, that I muſt content my ſelf with *Generals*.

§ XXXIII. Having dwelt ſo long upon the *inanimate* part of this *Syſteme* of things, I come now to conſider the *Animal* Kingdom; that *noble* and *manifeſt Repreſentation* of the *Power* and *Wiſdom* of the *Author* of *Nature*. One of *Democritus* or *Des Cartes*'s Diſciples, may perhaps undertake, to give ſome faint and imperfect kind of Explication of the *Celeſtial* Appearances, from their *Principles*, tho' how wretched their accounts of this Matter are, we have in ſome meaſure already ſhewn. But when they come to a *Plant*, or *Animal*, they are perfectly at a loſs, they can produce nothing coherent, or of a peice; their *Schemes* then, are like the effects of the caſual *concourſe* of *Atoms*, an odd inconſiſtent Mixture of things, that has neither Form, nor Beauty. For ev'ry part of theſe, is ſo exactly adapted, to ſome wiſe *Deſign*, ev'ry thing is ſo fitted, to its own proper uſe; and theſe Uſes are ſo manifeſt and evident, that they clearly argue, an infinite *Wiſdom*, an exact and exquiſite Knowledge, in the Laws of *Geometry* and *Nature*, that nothing is ſufficient for, but a *Being* abſolutely *perfect*. I ſhall here, as I did in the *Celeſtial Philoſophy*, give ſome general *Scheme*, of the *Animal Fabrick*, and *Oeconomy*; and ſhall confine my *Speculations*, to the *Humane Structure*, as being the moſt perfect, we are acquainted with, and which being once fully underſtood, the reſt will eaſily follow. I ſhall begin with the proceſs of the *Aliment* and the *Circulation* of the Blood.

§ XXXIV. The Meat being groſsly divided, by the Teeth, and ſoftened by the *Saliva*, is through the *Gullet*, by the Conſtriction of its *Fibres*, thruſt into the

Stomach; where being ſwell'd and farther ſoftned by the *Succus* of its *Glands*, and the Liquors taken in, by the perpetual Motion of the Coats of the *Stomach*, againſt one another, the *Muſcles* of the *Midriff* and *Abdomen* employed in reſpiration, its parts are broken, and their intimate Coheſions diſſolv'd. And by this *preſſure* of the ſides of the *Stomach* upon the contain'd *Aliment*, it is thruſt into the *Inteſtins*; at its entry into which, it is irrigated with the *Bile* and *Sweetbread-juice*, the one to ſweeten, the other to dilute the *Chyle*, by the *vermicular* Motion of the *Inteſtins* (ariſing from the alternate Action of their *Spiral* and *Longitudinar Fibres*) the *preſſure* of the *Midriff* and the *Muſcles* of the lower Belly, the groſſer parts are deriv'd downward, to be thruſt out of the Body, while the finer, are ſqueez'd into the narrow *Orifices* of the *lacteal* Veſſels, which open into theſe *inteſtines*; whence in ſlender Chanels they are carried into the *Glands* of the *Meſentery*, receiving firſt a fine thin *Lymph* from the *Lpmphatick* Ducts which dilutes this *Chylous* fluid, and ſcours its containing Veſſels, which from the *Meſenterick Glands* unite in larger Channels, and paſs directly into the common *Receptacle* of the *Chyle*, which is a Baſon, form'd for it by the Union of theſe *Lacteal*, and *Lymphatick* Veſſels; from thence in one Duct, it aſcends into the *Thorax*, and about the Heart ſometimes dividing, it immediately unites again, and creeping along the *Gullet*, it paſſes on to the left *Subclavian* Vein, where in one or two Mouths, it opens into that Veſſel, and there mixes with the Blood, and *circulates* with it, which *Circulation* is thus perform'd. The Veins (in a continued Channel with the *Arteries*,) bring the Blood from the Extremities of the Body, and all uniting in two large Veſſels, whoſe ſides diverge, form the *Vena Cava*, *Aſcendens* and *Deſcendens*, which two likewiſe join at their entry into the right Ear of the Heart, which in its *Relaxation* or *Diaſtole*, receives the Blood from them, and in its conſtriction or *Syſtole*, thruſts it into the right *Ventricle*, which is then its ſtate of Remiſſion: which when contracted, drives it through the *Arteria Pulmonalis*, into the *Lungs*; whence it is receiv'd, in an uninterrupted Channel, by the *Vena Pulmonalis*, and is carried into the left *Auricle* of the Heart, then open to receive it; by whoſe conſtriction, it is diſcharged into the left *Ventricle* then likewiſe dilated, by whoſe contraction it is puſhed into the *Aorta*, which bending a little upwards, ſends forth the *Cervical* and *Axillary Arteries*, the reſt turning down again, forms the deſcending Trunk, and theſe dividing into innumerable leſſer Channels, carry the Blood to the ſeveral parts of the Body, where leaving ſome of its Particles proper for their uſe; the reſt is ſent into the *Veins*, which are nothing but the returning *Arteries*; and thus the Blood is carried about in a perpetual *Circle*, from the *Arteries* into the *Veins*, and from theſe to thoſe; and in this *Circulation*, duly perform'd, Life and Health conſiſt.

§ XXXV. As it is plain from what has been ſaid, that it is only the Blood, that is recruited by the *Chyle*, ſo is it likewiſe evident from thence, that it is only from the Blood, that all the Expences of living are furniſhed, and that all the *Secretions* of what kind ſoever are deriv'd. Now theſe *Secretions*, are made by the aſſiſtance of the *Glands*, and a *Gland* is nothing but the *Convolution* or various folding, of the *Evaneſcent Artery*, whoſe laſt Branches muſt be *Cylindrical*. This *Cylindrical Artery*, in its windings, ſends out ſeveral little Ducts, of equal *Diameters*, which ſometimes unite in one common *Pore*, ſometimes run into a common *Baſon*. This Structure is evident, in all the larger and more conſpicuous *Glands*, ſuch as the *Inteſtins* with their Secretory Ducts, the *Lacteals*, the *Teſticles*, and ſome of the *Conglobat Glands*; and may be ſeen in all the reſt if they happen to be obſtructed, and ſo ſwell to become viſible. And therefore the ſame is reaſonably to be concluded of all the *Glands*, ſince

Nature is conſtant and uniform in her Actions, and produces ſimilar Effects by ſimilar Inſtruments. Now the Nature of the *Secretions* themſelves depend upon theſe three things. 1. The different *Diameter* of the *Orifice* of theſe *Secretory* Ducts, whereby Particles of a *Diameter*, greater than that of this Duct, are excluded. 2. The different *Angle*, which this Duct makes, with the Trunk of the *Artery*; for it is already demonſtrated, that all Fluids preſs the ſides of the containing Veſſel, and that in a direction *perpendicular* to theſe ſides; and this is evident in the *pulſation* of the *Arteries*, ſince it is, to that *preſſure*, this *pulſation* is owing. It is likewiſe evident that the Blood is urg'd forward by the Force of the Heart, ſo that the Motion of *Secretion* muſt be compounded of both theſe Motions. Now tho' this *lateral preſſure*, is greater, when the *Velocity* of the *longitudinal* Motion is ſo, yet it is not in the proportion of this *Velocity*; for this *preſſure* is always ſomewhat even, when the Fluid is at reſt, and is then in *proportion*, to the *Specifick* Gravity of the Fluid, nothing elſe being in this Fluid to produce this *preſſure*, and in a Fluid urg'd by a *Longitudinal* Direction, as the Blood in the *Arteries*, this lateral *preſſure*, is in a compound Proportion of both; whence it is evident that if two Particles of equal *Diameters*, but of unequal *ſpecifick* Gravities, arrive with the ſame *Velocity*, at an *Orifice* capable of admitting either of 'em, yet they will not both paſs, becauſe their *Motion* of *Direction* is different: So that this Diverſity in the *Angles*, theſe *Secretory* Ducts make with the *Trunk* of the *Artery*, ſeems altogether neceſſary to account for the poſſible Diverſities of ſecern'd Fluids, ev'n admitting their *Diameters*, and Figures, to be the ſame. For it is not to be doubted, that the Blood is a *Hetrogeneous* Fluid, and contains parts of different *Spetifick* Gravities, different Coheſions, and of different Denſities; and the ſeparated Fluid muſt be *Homogeneous* to perform the uniform Functions of Life.

3. The different *Velocities*, with which

the Blood arrives, at the *Orifices* of theſe *Secretory* Ducts, for ſince the *Secretions* are made in form of a Fluid, there is no poſſible Reaſon can be aſſign'd, why ſome *Animals* are of a ſoft looſe Texture, and Union of ſolid Parts, and why one part of the Body is of a tender, looſe, eaſily ſeparable Texture; others of an harder, firmer, and more cloſe Coheſion, but this different *Velocity* of the Blood, at the *Orifices* of the ſeparatory Ducts. And tho' the Diverſity of the *Diameters* of theſe Ducts, is certainly that which is of greateſt *Moment* in this Affair of *Secretion*, yet it is impoſſible to account, for the *ſimilarity* of the ſecern'd Fluids from ſo *Heterogeneous* a Fluid, as the Blood is, from this alone. For ſuppoſe, (as my worthy and learned Friend Dr. *Cockburn* has very juſtly reaſoned) the *Diameters* of the Particles of *Urin*, *Gall* and *Semen*, to be as 1, 2, 3. The *Diameters* of the *Secretory* Ducts, of the *Kidneys*, *Liver* and *Teſticles*, muſt be in the ſame *Proportions*. Now tho' upon this ſuppoſition of only different *Diameters*, the Particles of *Gall* and *Semen* cannot be ſeparated in the *Kidneys*, yet the Particles of *Urine* and *Gall* may be ſeparated by the *Excretory* Ducts of the *Teſticles*, the *Diameters* of the Particles of theſe Fluids, being by ſuppoſition, leſs than that of the *Diameter* of the *Excretory* Ducts of the *Teſticles*. So that upon this ſuppoſition of only different *Diameters*, it is impoſſible to account, for the *Homogeneity* or *ſimilarity* of the *ſecerned* Liquors: for all the Particles of whatever kind, that are leſs than the *Diameter* of the *Secretory* Duct, muſt be indifferently ſeparated there. But from this general view of the Nature and Manner of *Secretions*, the particular ones may be underſtood. *Nutrition* is perform'd by a *Secretory* Duct, ariſing from the terminating *Artery*, which carries a ſuitable Portion of the Blood, to every part to be nouriſhed, ſo that ev'ry point in the Body, muſt be the *termination* of a *Secretory* Duct; through which a proper part of the Blood is brought. The Blood being brought by the *Arteries* to the Brain; the *Capillary* parts of theſe *Arteries* by innumerable *convolutions*, form innumerable little *Glands*, of which it's *Cortical* part conſiſts; in theſe *Glands*, the finer, and more ſubtile, *Acid* Particles of the Blood, are ſeparated, and log'd in the ſlender ſmall *Tubes* of the *Medullary* parts, which are the beginning of the *Nerves*. Theſe *Nerves* are Bundles of fine ſmall Pipes, ariſing from theſe infinitely many little *Glands* of the *Cineritious* part of the Brain; and terminating in all the points of the Body; ſo that properly, they are only the *Secretory* Ducts of theſe little *Glands*, and the *Secretory Pores* of the *repoſitories* of the Animal Spirits; they are hollow but extreamly ſmall, ſo that tho' the Spirits move in them after the ſame manner, and by the ſame *Mechaniſm*, the Blood *circulates* through the *Arteries*, yet by reaſon of the many *convolutions* of the *Evaneſcent Arteries*, which form their original *Glands* in the Brain, to which they are *Excretories*; And the ſlenderneſs of their *Muſcular* Coats, the exceeding ſmallneſs of their *Cavities*, and their diſtance from the Heart; the *Velocity* of their Motion, in reſpect of that of the Blood, is very much abated; however this ſlow Motion keeps 'em very near full, and when theſe *Tubes* are quite full of this *nervous* Fluid, the *Animal* is active and watchful; when they are near empty, it is languid and drowſie; for this Fluid is the principal concurrent in *Muſcular* Motion, and the immediate *Organ* of *Senſation*. By the Motion of the *Heart*, through the *Emulgent* Branches, the Blood is brought to the *Kidneys*, and is there freed of its *Serum*, by their little *Glands*, and is receiv'd into the ſmall *Excretory* Ducts of theſe *Glands*, to be carried into the *Pelvis*, and thence by proper *Tubes* into the *Bladder*. Much after the ſame manner, are their proper Fluids ſeparated from the Blood in the *Liver*, *Sweetbread*, *Teſticles*, and the other *Conglobat* and *Conglomerate Glands* of the Body, ſo that it is needleſs to inſiſt on theſe.

§ XXXVI. The *Lungs* are compos'd of an infinite number of little *Lobes*, of different Figures, and Magnitudes, but ſo join'd as to leave but ſmall Vacuities between 'em. Each *Lobe* conſiſts of an infinity of ſmall *ſpherical Veſicles*, form'd by the Coats of the ſmall Branches of the *Trachea*; ſo that they may be conſidered (when blown up) as ſo many fine *Tubes* ending in little hollow *Spheres*; upon the ſides of theſe *Veſicles*, the Blood Veſſels in a fine *Net-work* are ſpread. Now before the *fœtus* is brought to Light, theſe *Veſicles* lie flat upon one another, and by their *preſſure* upon the Blood Veſſels, hinder its progreſs through them; but as ſoon as this *fœtus* enjoys the benefit of the Air, by its weight and *elaſtick* Force, this Air ruſhes in through the Pipes of the *Trachea* into theſe *Veſicles*, and blows 'em up, whereby they ſtand erect upon the *Trunks* of theſe little *Wind-pipes*, and give a free paſſage to the Blood through theſe Veſſels, ſpread upon their ſides. And when by the weight of the *Thorax*, and the

Action of the Muſcles thereof, with thoſe of the *Abdomen*, and *Midriff*, this *elaſtick* Fluid is thruſt out of the *Veſicles*, through the *Trachea* in *Expiration*; theſe *Veſicles* preſſing againſt one another, and the *elaſtick* Fluid acting upon the ſides of them, and conſequently, on the Blood Veſſels ſpread thereon, ſeparate the *Globules* of the Blood, which had Room and Liberty to unite in the wider Channels of the *Veins*; and by this ſeparation of theſe *Globules* of the Blood, from one another, renders it more capable to *circulate*, in the more narrow paſſages of the *Capillary* Veſſels. But, if I be not very much miſtaken, there is ſtill a more conſiderable uſe of this natural *Function* behind, and that is to form theſe *elaſtick Globules* of which the Blood principally conſiſts. It is undoubted Matter of Fact and obſervation, that the Blood conſiſts of a *Lymph*, which is the common *Vehicle*, ſeveral *Salts*, *Ramenta* of a thick conſiſtence, (which is probably the unform'd part of the *Chyle*, and Aliment) and theſe red *Globules*, of we are now ſpeaking; but ſometimes they are of different Colours, as *White*, *Blew* and *Purple*; theſe any body may diſcover with an ordinary *Microſcope*. Now it's certain, that theſe *Globules* may be burſt, as in obſtructions; or may be all exhauſted, as in violent *Hæmorrhages*, and yet be all recovered and recruited again; wherefore it is of neceſſity, that theſe *Globules* muſt be form'd ſomewhere in the Body from the *Chyle*. And ſince it's certain that they are not ſolid *Particles*, both by ocular inſpection and touch, and by the neceſſity they are under to change their Figures into oblong *Spheriods*, in the *capillary* Veſſels, as alſo from their Colour, and that *Acids* do actually deſtroy their Figures, and coagulate theſe *Globules*; it is highly probable, they may be little bubles, blown from the viſcid part of the *Chyle*, by the force of ſome more ſubtile *Elaſtick Aura*. Now no Place in the Body, but the *Lungs*, can afford this *elaſtick* Fluid; and this may be [illegible] the reaſon why the *Chyle* enters into the *Veins*; and theſe too only, which are juſt returning immediately to the Heart, to be ſent into the Lungs. For ſince in our groſs *Eliment* of Air, there is conſtantly loged, a finer *Elaſtick* Fluid, which is the principal Agent, in all the ſubtile Effects commonly aſcrib'd to the other, tho' the groſſer *Eliment* cannot, yet this finer Fluid, by that vaſt Force uſed in *Expiration*, may be thruſt in through the ſides of theſe *Veſicles*, to the Blood Veſſels; and ſeeing theſe Blood *Globules* muſt be generated ſomewhere, and ſince there is no part in the Body, this ſubtile *Elaſtick* Fluid can be ſqueez'd with ſufficient Force, to get through the ſides of the Blood Veſſels, but in the *Lungs*; it ſeems to me beyond all doubt, that theſe *Globules* are form'd there after this manner: The *viſcous* part of the *Chyle* being by the ſhorteſt and ſafeſt courſe poſſible, brought into the returning part of the Blood, is ſent from the right *Ventricle* of the Heart to the *Lungs*, and is ſpread upon the ſides of the *Veſicles* thereof of, in little fine *Tubes*, this fine *Elaſtick* Fluid being ſqueez'd, in the Act of Expiration, through a *Pore*, continued through the *Veſicle* of the *Lungs*, and the ſide of the Blood Veſſels, is forc'd into the *viſcous* part of the *Chyle*, which is runing by in the *Serum*, and by its *perpendicular preſſure* upon the ſides of that Cavity it forms, produces a ſmall little *buble*, of a certain magnitude, and thickneſs of Shell, from whence it has its Colour, and by the force of the ſucceeding Fluid, this little *buble* is broken off from the *Pore*, and carried along the *Artery*, and the *Coheſion* of the parts of the Shell of this *buble*, being greater than the force from without, whereby the thin *Serum* acts upon it, it is preſerv'd in its figure in all the various Motions of the compound Fluid of the Blood; and if it happen that theſe little *bubles* ſhou'd be burſt, (as they moſt certainly are by a thouſand Cauſes) when ever they come to the *Lungs*, they are new-form'd again, whereby the *circulation* is rendred conſtant and uniform. For ſhou'd theſe *Globules* be all deſtroyed, there muſt of neceſſity ariſe a general Obſtruction in all the *Capillary Arteries.* The manner of the Production of theſe little *bubles*, in the Blood by the *Elaſtick* Fluid, forc'd through the ſides of the *Veſicles*, and Blood Veſſels in the *Lungs*, is ſo obvious, that I ſhall inſiſt no farther upon it, ſince ev'ry body may ſee an inſtance of the ſame Nature, in mixing Oil with Vinegar, the Subſtance of which Mixture, when view'd, but with an ordinary *Microſcope*, appears to be nothing but an *infinity* of ſuch like little *bubles*, form'd by the immiſſion of the Air, and Vinegar, into little Shells of Oil. But from this one Principle, many of the deſpair'd of Appearances, in the *Animal Oeconomy*, may be made eaſie; and a thouſand Difficulties about the Cauſes of Diſeaſes, and the manner of the Operation of *Medicines* vaniſh. And this makes it look the more like truth, Nature being frugal in her Principles, but various in the effects thence ariſing. But it being both foreign to my Deſign, and unfit for the Limits I have preſcrib'd to my ſelf, to deduce all the *Corollaries* thence ariſing, I ſhall inſtance but in one Particular, and leave the reſt to another Occaſion.

§ XXXVII. A *Muſcle*, as I have hinted § XIII. of the preceding Chapter, is only a bundle of *Fibres*, of which all in the ſame Plane run *parallel*; the fleſhy part of the *Muſcles* is ſpongious, ſoft and lax; the *tendinous*, is only the fleſhy part compacted, the *Fibrils* of the one are divided into innumerable little *orbicular* Cells, form'd of two concave *Segments* of a *Sphere*; thoſe of the other, are hard and ſolid; theſe make the Head and Tail, which are always inſerted into ſome ſolid places of the Body; as to thoſe of the Belly of the *Muſcles*, each *Fibre* conſiſts of an infinite number of little *Fibrils*, ty'd together by tranſverſe ſmall Threads, which go from *Fibre* to *Fibre*, and are call'd *Membranous Fibres*; into thoſe *orbicular* Cells, enter an *Artery*, *Vein* and *Nerve*, the firſt and ſecond, to bring and carry back the Blood, the latter to let in (upon any Impreſſion communicated to it) its own proper Juice. Now it's very probable from its *Acid* taſte, that this *nervous* Juice, conſiſts of Particles which are pointed and fit to break the *Shells* of the *Globules* of the Blood: And upon an immiſſion of this Liquid of the *Nerves*, into the *orbicular* Cells of *muſcular Fibres*, the *Globules* of the Blood may be actually broken, and ſo leave the impriſoned *Elaſtick Aura*, to eſcape; by which means, theſe little *elaſtick* Cells of the *Fibres* muſt of neceſſity be blown up. And thereby their *Longitudinal Diameters*, from Cell to Cell ſtraitned: which wou'd contract the length of the whole *Fibre*, and ſo move that *Organ* to which one of the *tendons* is fixt. This is undoubtedly the true manner of *muſcular* Motion, and agreeable to the learned Mr. *John Bernoulli*'s Doctrine on this Head. And conſequently, all the *Geometrical Theorems* he has diſcovered about *muſcular* Motion, are now actual *Theory*, and Matter of Fact. But I ſhall have an occaſion of ſpeaking of theſe afterwards. Only now, The place of the Production of theſe *Globules*, and their Nature being thus determin'd, *a priori*, is a very evident demonſtration of the true Cauſe of *muſcular* Motion, which has been long thought uncapable of being explain'd. The broken Shells of theſe *Globules*, are carried back by the *Veins* to the *Lungs*, to be new-form'd, which is the reaſon that *muſcular* Motion is ſo conſtantly and uniformly perform'd, ſo long as the *Blood Globules*, and *Animal Spirits* are in ſufficient plenty. For the Motion of the Joints and Limbs the *Bones* which are the *Pillars* of the Body, are *articulated* one into another, and the one Extremity of the *Muſcle*, is faſtned to ſome ſolid part, and the other to the *Bone*, that is to move beyond its *Articulation*. So that the length of the *Muſcle* being ſhortned, the moveable Bone, muſt be drawn toward the fixt Extremity, according to the Manner and Determination, of the *Articulation*. Thus the Motions of all the more ſolid parts of the Body are perform'd.

§ XXXVIII. The Fluids of the Body are principally propell'd, by the Action of the Heart, and the *elaſtick* Force of the *Fibres* of the containing Veſſels. Now the Heart is a *Muſcle*, like other *Muſcles*, conſiſting of ſeveral Orders of fleſhy *Fibres*, of different Directions, it has two little *Ears* and as many *Ventricles*, which are Cavities for receiving or holding the Blood, as it comes from the ſeveral Veſſels, or is to be driven to different Places. The *Fibres* of this *Muſcle*, act by the *Longitudinal Diameters* of its *Muſcular* Cells being ſhortned, and ſo by the winding and ſpiral Direction of its ſeveral Orders of *Fibres*, the Cavities of the *Ears* and *Ventricles* are leſſen'd or conſtring'd. And it is obſervable that all the *Muſcular Fibres* of the Coats of the Veſſels, act after the manner already explain'd. But the *Membranous* Coats, meerly by their own *Elaſticity*, being ſtretch'd firſt by external Violence. Thus the ſides of all *Membranes* are bent or preſs'd outward by ſome included Fluid; but reſtore 'emſelves by their own natural Elaſticity; whereas when ever a Coat conſiſts of *Fibres* of whatever kind, excepting thoſe for *Senſation* or *Nutrition*, it is a ſure *Indication* that this Coat acts as a *Muſcle*; for Nature does nothing in vain, and wou'd never have diſtinguiſh'd a Coat into *Fibres*, but for *Muſcular* Action, when a continued *Membranous*, or *Tendinous* one, is more capable of acting by its own *Elaſticity*. So that the Nature of the Coats, and of their conſtituent *Fibres*, of the Channels, being known, together with the Range and Direction of theſe *Fibres*, it is eaſie to know the manner of their operating upon the included Fluid. The Coats of the *Gullet* are three; the outermoſt *Membranous*, the ſecond fleſhy and *Muſcular*, turning obliquely from the uppermoſt end of the *Oeſophagus* to the *Stomach*; the third, is tendinous and *muſcular*, of white ſlender *Fibres* diverſely interwoven. The *Stomach* has four Coats, the innermoſt is Carpet-like, of white ſhort tendinous *Fibres* ſtanding *perpendicular* upon the next Coat, which is *nervous* and extreamly ſenſible; the third is fleſhy and *Muſcular*, of ſtraight and circular *Fibres*; the fourth *Membranous* from the *Peritonæum.* The *Guts* conſiſt of three Coats, the innermoſt is of the ſame nature with that of the innermoſt of the *Stomach*, the ſecond is of two Orders of *Muſcular Fibres*, *Longitudinal* and *Spiral*, the third is common and *membranous*, ariſing likewiſe from the *Peritonæum*. The *Nerves*, as I have before ſaid, are a bundle of fine, ſmall, ſlender *Pipes*; wherein the Animal Spirits are treaſur'd up for the Expenſes of Motion and *Senſation*; they ariſe from the *Glands* of the *cineritious* part of the Brain, and are terminated in all the points of the Body; ten pair deſcend immediately through proper Holes of the *Skull*, and ſerve the adjacent Parts, and particularly the *Organs* of four of the Senſes; the reſt in a large bundle, are let down by the Cavity of the

Vertebræ, and at fit Places are ſent forth to actuate the ſeveral inferiour parts of the Body. The *Arteries* have three Coats, the outermoſt is a fine Web of *Nerves*, and Blood Veſſels, for the nouriſhment of theſe other Coats; and for the *Muſcular Action* of the intermediate one, which is made up of ſeveral *ſtrata* of *Spiral Muſcular Fibres*, according to the bigneſs of the *Artery*. The third is a cloſe tranſparent *Membrane* very ſtrong and compact, to keep in the Blood which otherwiſe upon the dilatation of the *Artery*, wou'd tear the *Muſcular Fibres* aſunder. The *Veins* have the ſame Coats with the *Arteries*, only the *Muſcular Spiral Fibres* are thinner, becauſe of the leſſer force of the Blood againſt the ſides of the diverging *Veins*, than thoſe of the converging *Arteries*. From this general account of the ſtructure of the *Veſſels*, their Actions upon the incloſed Fluid may be eaſily underſtood, the ſhort erected *Fibres* ſerve for the attrition of the *Aliment*, and for ſtraitning the Cavity of the *Guts* and *Stomach*; the *oblique Fibres*, which make but few turns ſerve to propagate gently the included Fluid, the *Longitudinal* ones to move the Veſſel, and the included Fluid, up or down in a direction *parallel* to its length, by encreaſing this dimenſion and thereby leſſening the other, *i. e.* the tranſverſe *Diameter*; the *Spiral* ones by ſqueezing it tranſverſely, and ſo encreaſing it in length or leſſening it in breadth. Thus the Blood being puſht by the contraction of the Heart into the *Arteries*, diſtends their Coats along their whole length, till the force of the natural *Elaſticity* of the *Membranous* Coat, be equal to the force of this Impulſe; then that *Elaſticity* of this Coat beginning to act, at the ſame time the *nervous* Juice is ſqueez'd out from the *Nerves* by this dilatation of the ſmall *Arteries*, among the *Originating Nerves* in the Brain, and ſo brings the *Muſcular Fibres* into Action, after the manner already explain'd. And both theſe Forces acting at once, propell the Blood in a continued Stream, through the uninterrupted Channels of the *Veins* and *Arteries*. And the impulſe of the Heart, propagated only by the *Membranous* Coat, is that which when felt, is call'd a *Pulſe* or *Pulſation* of the *Artery*.

§ XXXIX. All *Senſation* is perform'd by the immediate Action of the finer and more fluid parts of Bodies, upon the *Organs* of Senſe; the Impulſe communicated by theſe ſubtile parts of Bodies, upon the *Organs* fitly diſpoſed, is through them tranſmitted to the *Nerves*, appropriated and contriv'd for ſuch a Senſe, and through them to the Brain. Thus in *Viſion*, the *Light* reflected from the Surfaces of Bodies, is tranſmitted through the *Humours* of the Eye, and congregated upon the *Retina*, in the ſame manner it was reflected from the Body, and thereby an Impulſe modified after a certain manner, ſtrikes the *filaments* of the *Optick Nerves*, which convey this Impulſe to the Brain. In *Hearing*, the Sound after diverſe Modifications, in its paſſage through the *Meatus Anditorius*, ſtrikes on the *tympanum*, which moving the Bones of the Barrel, and they the incloſed Air of the *Labyrinth*, the *Auditory Nerves* there, are mov'd, after the ſame manner they wou'd have been, had the common Air acted upon them, with the Advantage of a better qualified and gentler Impulſe than they cou'd have had otherwiſe. In *Smelling*, *Taſting*, and *Touching*, the *Effluvia* and more ſubtile parts of Bodies, act immediately upon the *Nerves* themſelves, and they communicate this Action to the Brain: So that in ſome manner, all *Senſation* is nothing but *Touching*, ſeveral ways diverſified. *Generation* is nothing but *Accretion*, for it is beyond all doubt, that all *Generation* is from a preceding little *Animal* lodged in the Male. I have demonſtrated the *Mechanical* production of *Animals*, to be impoſſible and unconceivable; there is nothing in an *Animal* but an *infinity* of branching and winding Channels, and their contain'd Fluids, and no Diſpoſition or Arrangment of either, can produce an *Animal*, ſince all the parts muſt be form'd together; we find ſome little *bubles*, or Blood *Globules*, may be form'd out of the *Chyle* in the Veſſels, and one kind of Liquor may be ſeparated from another, out of the Blood in the *Glands*, and theſe are all the Productions an *Animal* is capable of, which can never reach to that wonderful Number, and Diſpoſition of parts, an *Animal* conſiſts of. Now, ſince it is abſurd to think *God Almighty* is confin'd to a new Creation, in ev'ry *Generation* of an *Animal*, and that theſe *Animals* themſelves are conſpicuous in all Male Seeds; it is plain that they muſt have been all created at once; and lodg'd in the Loyns of the Original pairs of all the *Species* of *Animals*. Likewiſe the Fluids, if they did not move in the Channels of theſe ſmall *Animals*, wou'd corrupt and deſtroy their containing Veſſels. It's evident then that they muſt *circulate* after a manner proper to 'emſelves; tho' doubtleſs the *Velocity* of their Motions is perfectly accommodated to the ſmallneſs of their *Bulk*, and the ſlenderneſs of their ſolid parts; and ſince theſe Fluids cannot move, without ſome inſenſible *Evacuations* and *Secretions*, this Loſs muſt be repair'd ſome way or other. Wherefore, it is not improbable they may lurk ſomewhere in the Male, in ſome proper Place, till they be fitted to be carried off in the ſoft and tender Fluid of the *Semen*, to be afterwards log'd in the Female; where they are fitted with Accommodations, ſuited to this Degree of Growth and Perfection, till they arrive to the next Period of their Lives; *viz.* to bear the *Light* and the *Air*. We are certain that the *Seeds* of *Plants* are nothing but little *Plants*, perfectly form'd, with Branches and Leaves duly folded up, and involv'd in *Membranes*, or ſurrounded with *Walls* proper to defend them in this tender Eſtate, from external Injuries; and that *Vegetation* is only the unfolding and extending of theſe Branches and Leaves, by the Force of Juices rais'd by Heat, in the ſlender *Tubes* of the *Plant*. We know that the Eggs of *Animals* are only an *Uterus* for a little *Animal*, furniſhed with proper Food, and fenc'd from external Injuries; and we know likewiſe that all the Effects of *incubation*, is ſupplying a fit degree of Heat and Warmth, to make the congeal'd Fluids flow, and more eaſily paſs into the nouriſhing Channels of the included *Animalcul*; and the Heat of the *Sun* or of our *Culinary* Fires, when duly adjuſted, produce the ſame very Effects with that of the *Females*. We are ſure, that all the ſeveral *Transformations* of *Inſects* and other *Animals*, is nothing but the *Expanſion* of their parts, and the breaking of the *Membranes* that folded 'em up by the Augmentation of theſe parts; that all the ſeveral Figures and Shapes they put on, is owing to the ſeveral *Membranes* they are involv'd in. Now were there no other Argument, but the *Analogy* between the manner of the *Generation* and *Transformations* of theſe lower, and the more noble *Animals*, it were ſufficient to perſuade any one, who conſiders the ſimplicity and uniformity of Nature in all her Works. But this, with theſe already mentioned put it beyond all doubt; that we are all deriv'd from one *Seed*, and were once all actually in the Loyns of our firſt Parent, and have been ever ſince, growing to our preſent Eſtate.

§ XL. From this general view of the *Structure* of the parts, and of the manner how the *Animal Functions* are perform'd, ev'ry body may ſee how *wonderfully we are made*; how wiſely our ſeveral parts are fitted for their Uſes; how juſtly our Fluids are contriv'd and diſpos'd, to make theſe uninterrupted *Circulations* wherein Life conſiſts; how ſimple, and yet how ſufficient, the Cauſes of all thoſe various Motions, the *Animal* performs, are. It is impoſſible duly to conſider theſe things without being rapt into admiration of the infinite *Wiſdom* of the *Divine Architect*, and contemning the arrogant Pretences of the *World* and *Animal Wrights*, and much more the Productions of Chance or juſtling *Atoms*; for ſince even *Mechaniſm*, aſſiſted by ſome kind of *Art* and *Contrivance*, does ſo miſerably blunder in the Undertakings of this Nature (as we may ſee in all the *Schemes* of the *Projectors* upon theſe Heads) we may be aſſured *blind Chance* and *jumble* cou'd never produce ſo beautiful ſimple and uniform Effects. Cou'd any of our *mechanical* Undertakers, with all their skill and cunning, make but an *Inſect* or a *Plant*, with the ſame Faculties and Qualities that Nature does; we ſhou'd begin to hearken to 'em. But they are ſo far from that, that the moſt exact and nice Performances of *Art*, come ſo far ſhort of the dead *Organs* of *Animals*, or the *inanimate* Productions of Nature, that a weak Eye may diſcover the vaſt Difference. Wherefore of unavoidable Neceſſity, *He that form'd the Eye muſt himſelf ſee, and he that made the Ear muſt himſelf hear, and he that indu'd Man with Wiſdom muſt himſelf underſtand*; and he that contriv'd ſo wonderfully and wiſely, and form'd ſo juſtly and exactly, all things both animate and inanimate, muſt needs *Himſelf be*.

But I proceed to make ſome reflections upon the particular Inſtances of *Council* and *Wiſdom* in the *Animal* Fabrick.

§ XLI. The Skin with its parts is what offers itſelf firſt; The *Scarfskin* being uppermoſt, is compos'd of ſeveral Lays of ſmall *Scales*, which cover one another more or eſs, or lye thicker, according as it is thicker n one part of the Body than another; between theſe *Scales* the *Excretory* Ducts of the *Miliary Glands* of the true Skin open. *Lewenhoeck* reckons that about one Cuticular *Scale*, 500 ſuch Ducts may lye, and that a Grain of Sand will cover 250 of theſe *Scales*, ſo that one Grain of Sand will cover 125000 *Orifices* of theſe *Excretory* Ducts. Now what a prodigious Number of ſuch *Glands* muſt there be on the Surface of the whole Body! Into ev'ry one of theſe *Glands* an *Artery*, *Vein* and *Nerve* do enter; ſo that we may gueſs how prodigious the Number of *Organs* in an Animal Body muſt be, from theſe that are viſible to the Eye aſſiſted with an ordinary *Microſcope*. Theſe *Glands* ſecern the Sweat and inſenſible Perſpiration. And of Neceſſity they muſt be many, ſince *Sanctorius* obſerves, that through them fifteen Ounce weight of a Fluid paſſes in 24 Hours. Next under the *Scarfskin* are the *Papillæ Pyramidales*, infinite likewiſe in Number; they are the Extremities of the *Nerves* of the *Skin*, and ſerve more immediately for the Senſe of *Feeling*, to convey the Impulſe receiv'd along the *Nerves* to the *Brain*. About theſe, the *Nerves* and other Veſſels make a fine *Web*, all cover'd over with a mucous Subſtance, to moiſten theſe *Papillæ Pyramidales*; and then under this the *Miliary Glands* themſelves are plac'd, protruding their *Secretory* Ducts up, to the Surface of the *Scarfskin*; upon which there are many *parallel* Lines, and theſe interſected by others, and in each interſection a Hair is planted. In the *Summer* the Skin is thinner and ſofter, in *Winter* more compact and hard, by reaſon of the heat and cold of theſe different Seaſons. The *Scales* of which the *Scarfskin* is compos'd is deſign'd to fence the *Orifices* of the *Secretory* Ducts of the *Miliary Glands*, and to hinder Objects from making too painful and exquiſite an Impreſſion on the *Nerves*, and to skreen them from external Injuries; the Skin it ſelf is deſign'd to wrap up the whole Body, to ſuſtain and to keep the *Papillæ Pyramidales* in their Places, and the *Miliary Glands* from being diſordered, to receive the Impreſſions of external Objects, and to be the *Organ* of the Senſe of *Touching* and *Feeling*. Now what can be more wonderfully contriv'd than this exterior part, if the *Papillæ Pyramidales* or the *Miliary Glands* had been few and large, then the Intervals had been without any Senſe of *Feeling*, and ſo might have been deſtroy'd without our Knowledge, to the danger of the whole; and theſe *Intervals* had not been freed from the noxious parts, which are here thrown out of the Body by theſe *Glands*; but by their infinite Number, ev'ry point and *Atom* of the *Animal* Body is taken care of. But that which is yet moſt wonderful, is the apt proportioning this Senſe of *Feeling*, to the Actions and Impulſes of the Bodies among which we live. For had our Senſe of *Feeling* been ten or twenty times as exquiſite as it is, then we ſhou'd have been in perpetual Torment, ev'ry Hair had been a Dagger, the touch of a Feather, or of the Wing of a *Fly*, had made us cry out, we ſhou'd not have dar'd to have approach'd our Cloaths or our Beds; in ſhort, we had liv'd in perpetual Miſery; and had it been as many times duller, or more *callous* than it is, we had loſt ſome of the moſt exquiſite Pleaſures of Life, our tendereſt parts had been as inſenſible as our Hairs or Nails, and might have been torn away or conſum'd, without our Knowledge or Concern. Whereas by this nice adjuſtment of the Senſe of *Feeling* to the Impulſes and Actions of Bodies round us, we can live in indolence from the Diſturbance of the *effluvia*, and Actions of little Bodies that are neceſſarily in Motion; and we feel ſenſibly enough, to hinder us from hazarding the Ruin of our Fabrick. And univerſally indeed in all *Animals* whatſoever, this Senſe is adapted to the Circumſtances wherein they live, which is a notable Inſtance of *Council* and *Deſign* in the formation of theſe Parts. And it is worth noticeing, that this Senſe of *Feeling* is rendred more exquiſite and ſenſible, or more dull and imperceptible, as it is more or leſs uſed; for it is highly probable, that the *Scales* which compoſe the *Scarfskin*, and guard the *Organs* of this Senſe from being violated, do ariſe from the *preſſure* of touching Bodies upon the Mouths of the *Superficial* Veſſels at different times, by which ſome drops of a viſcid Fluid is forc'd out, which there drying and hardning, becomes a ſmall *Scale*; and therefore the oftner the Mouths of theſe Veſſels are preſs'd upon, or the oftner we uſe theſe *Organs* of *touching*, the more of theſe *Scales* are form'd, and the Skin becomes the thicker, and ſo a *callouſneſs* grows upon it: And conſequently, the more moderately we uſe the Pleaſures of Senſe (the moſt exquiſite of which lie in that of *Feeling*) the more lively and ſenſible they are; and the more immoderately we uſe theſe Pleaſures, the leſs they are ſo; which is a wonderfull wiſe Contrivance of the *Author* of *Nature*; for were it otherwiſe, ſo diſtracted is the moſt part of Mankind, that they wou'd certainly deſtroy themſelves, ſince we ſee where there is both Sin and preſent Puniſhment, they are not kept from Exceſſes that way.

§ XLII. Having already ſhewn the wonderful yet ſimple ſtructure of the *Muſcles*, I have little more to add upon that Head. For tho' ev'ry ſingle *Muſcle*, of which there are about 446 in a Humane Body, either in its *Figure*, *Situation* or *Inſertion*, has ſomething that ſpeaks *Deſign* and *Council*; yet ſeeing *Borelli* has written a whole Book to ſhew this, and to inſtance in all the Particulars, were to tranſcribe it, or to write a whole *Syſteme* of *Myologie*, I ſhall refer my Reader for his full Satisfaction in this Affair, to that learned and ſurpriſing Book *De motu Animalium*, and ſhall only ſuggeſt a few Inſtances. 1. Then the manner of the Diſpoſition of the *Muſcles* of the *Fingers* and *Toes*, is admirable. We know that for the uſes of Life, theſe *Muſcles* were to be ſtrong and large, that they might be ſufficient for the various, and forceable Motions of theſe *Organs*; now had they been ſituated near or about theſe Parts, they wou'd have altogether diſturb'd their Motions, and made ~~theſe~~ Places ſoft and ſpungy, and conſequently unfit for graſping and going: And to avoid this, the *Infinitely wiſe Author of Nature*, has plac'd them at a conſiderable diſtance from theſe *Organs*; and that ev'n there, they might not in bending the *Arm* or *Leg*, riſe up and fill thoſe Places with their *Bodies* or *Tendons*; he has ty'd them to the Bones by *Annular Ligaments*; and alſo that one *Tendon* might not be interrupted in its Courſe by another, he has ſlit ſome, that others might paſs through them undiſturb'd, this is ſuch a wonderful Inſtance of Wiſdom and Deſign, that none can paſs it over without Admiration. 2. It is very obſervable that in *Muſcular* Motion the Expenſe of *Animal Spirits*, is not in Proportion to the Labour the *Animal* is at. Mr. *Bernoulli* in that *Curious Meditation* about *Muſcular* Motion, printed in the *Acta Lipſiæ* 1694, has demonſtrated, that the Expenſes of *Animal Spirits*, are in a much leſs Proportion, than the elevated Weights; for ſuppoſing the *Animal Spirits* expended, in burſting the Blood *Globules*, in the *veſicular* Cells of the *Muſcular Fibres*, to be as 8, then a Weight four times as great, as when they are but as 5, may be lifted. So that when the *Animal Spirits* are but as 5 to 8, the Weight ſuſtain'd by 'em ſhall be as 1 to 4. And the like of the other Proportions of the *Animal Spirits*; eſpecially the Difference becomes moſt ſenſible between theſe *Animal Spirits* and the ſuſtain'd weights, when theſe *Spirits* are expended in greateſt Quantities. Now what a wonderful wiſe Contrivance and *compendium* of Nature is this? Here in great Labour, the *Animal Spirits* which are the Subſtance, or rather, the very Eſſence of the Blood, are ſav'd as much as is poſſible; ſo that a Man who is obliged to hard Labour, is not reduc'd to the neceſſity of having twice or four times as much Victuals, as one that is under no neceſſity to work. we all know that the Spirits are the moſt precious things in all the *Animal Body*, by which we move, and our Blood *circulates*, *i. e.* we live; by which all the Pleaſures of Life are reliſhed, and all *Senſation* perform'd; by which we have that Liveline ſs and Agility, that Chearfulneſs and Tranquillity, that actuates all our Enjoyments; and without which, we are languid, and dull, unactive, and thoughtleſs. Now this, ſo neceſſary and uſeful a Subſtance, was to be ſav'd by all means poſſible, and agreeable to the Neceſſities of Life, and we ſee the wiſe Author of Nature, has taken wonderful Care, that no Expenſes ſhou'd be made therein that cou'd be avoided. 3. What a ſtrange variety of Motions

tions are our *Organs* capable of? There is no poſſible one, that might be uſeful to us that we want, and how wonderfully is the whole *Machin* adjuſted? For our erect Motion, the Center of Gravity is ſo diſpos'd, as to fall, by a Line drawn from it to the Center of the *Earth*, always in ſome part of the *parallelogram* form'd by the outer ſides of our Feet, and two Lines drawn by our Toes and Heels, by which means we are kept from tumbling, and if at any time we chance to throw this Line without that Space, and ſo be in hazard of falling, our Arms, and the various Motions of our Head, and Breaſt, immediately bring it back within that Space. Thoſe *Animals* that are deſign'd for flying or ſwiming on the Surface of the Water, have all their ſtrongeſt *Muſcles* upon their Breaſts, whereby they are kept in the fitteſt Poſture for ſwiming or flying, the *Center of Gravity* being ſo diſpoſed as naturally to keep their Heads erect. And in thoſe *Animals* that live within the Surface of the Waters, there is a

Bladder fill'd with Air, whoſe *Orifice* is endow'd with a *Muſcular Sphincter*, by which they let out and take in the *Air*, to render them *Specifically* lighter or heavier, than the Fluid they ſwim in, and ſo ſink or emerge as their Occaſions prompt them, or as they paſs to a *Specifically* lighter or heavier *Element*; for by taking in more *Air*, they become lighter than they were, and ſo neceſſarily emerge, and by letting out ſome, they become heavier, and ſo ſink. But this Bladder is commonly full of *Air*, which is under ſome Degree of Condenſation, from the *preſſure* of the *Muſcular* ſides thereof; ſuch to wit, as renders 'em in an *Æquilibrium* without any Pain, with that kind of Fluid they live moſt in, and they commonly alter their *Æquilibrium*, by the Compreſſion or Expanſion of this Bladder, which being cut out, the Fiſh ever after, either ſwims on the Surface or ſinks to the Bottom. Birds and Fowls that ſleep, reſting on one Foot to eaſe the other, naturally lay their Heads under their Wings, that ſo the *Center* of the *Gravity* of their whole Body, may fall upon the Foot they ſtand on, and the *Animal* be preſerv'd from overturning; and thoſe Fowls that ſleep ſo on the ſmall Branches of Trees, incline a little backwards, that their Claws by the *Gravity* of their Body, without any *Muſcular* Contraction, may graſp the Branch more ſtrongly. Theſe are wonderful Inſtances of *Divine Wiſdom* and *Providence*; but thoſe who pleaſe to conſult that noble Work of *Borelli*'s, will find to their Satisfaction, a thouſand ſuch Inſtances, relating to this Head alone of *Muſcular* Motion.

§ XLIII. The Bones conſiſt of hard compacted *Fibres*, ty'd together by *Tranſverſe* ones, after the manner of the *Muſcles*; they are nouriſhed by Blood Veſſels which enter their Subſtance at ſeveral Places, which upon the compleat growth of theſe *Bones*, are ſo ſtraitned as to admit only what is ſufficient to repair their Decays. All the conſiderably thick *Bones* are either hollow or ſpongious, and both ſorts contain an *oleaginous* Subſtance, preſerv'd ſerv'd in little *Veſicles*, which by the Heat of the Body, is exhal'd through the porous Subſtance of theſe *Bones*, to ſupple and anoint their *Fibres*, that they dry not, and thereby grow brittle. All the *Bones* are cover'd with a very ſenſible *membrane* call'd the *Perioſteum*, each large *Bone*, is conſiderably bigger at the Extremities than at the middle, and that for very wiſe Ends and Purpoſes: For 1. Thereby the *Articulations* are made ſtronger, for had they been leſſer or equal to the middle, our Limbs had been in hazard of being diſjointed upon ev'ry Occaſion. And 2. By the largeneſs of theſe *Tubercles*, it comes to paſs, that in all the *Revolution* of the joint. The *Tendon* is kept at the ſame diſtance of the *Semidiameter* of the *Tubercle* from the Center thereof, *i. e.* the Center of Motion; whereby, in the *Articulations* of the Shoulder and Knee eſpecially, the Arm and Leg, is capable of moving round, more than a *Semicircle* which by, no other Contrivance poſſible, but this cou'd be obtain'd. There are ſeveral and various manners of *Articulations* of the *Bones* into one another, wonderfully fitted for the Motions of the ſeveral Members, one is like *Ball* and *Socket*, by which the *Bone* can move equally any way; as the *Thigh-Bone* with the *Iſchium*; others are by way of *Charnal*, as the *Radius* with the *Ulna*; a third are only ty'd together by intervening *Cartilages*, as the *Vertebræ* of the Back. Now all theſe different *Articulations* are from the Neceſſity of the *Situation*, or Motion of theſe *Bones*. The *Bones* in order to be the moſt convenient that might be, ought to have been as light, as was reconcileable with a ſufficient degree of Strength, that the Inſtruments of Motion, might not require too great an Expenſe of Spirits, to move them, and that the *mechanical Machin* might not become a Burthen to themſelves; now the wiſe *Author* of *Nature*, has wonderfully provided for this, for he has made 'em light, by evacuating their middle Subſtance, and yet they are ſtronger by very far, than if they had compos'd one ſolid *Cylinder*; for *Galileo* has demonſtrated, that of two *Bones* of equal lengths, and of equal Number of *Fibres*; the Strength of the one is to the Strength of the other, as their *Diameters* are; ſo that a hollow *Bone* of a double *Diameter*, to a cloſe one of the ſame Number of *Fibres*, is as 2 to 1, or the firſt is twice as ſtrong as the ſecond. This is moſt conſpicuous in thoſe *Animals* that are form'd to fly; it is wonderful, how light and yet how ſtrong, the Quils of their Feathers and their *Bones* are, and this wonderful wiſe *End*, cou'd no otherways be obtain'd but by this Contrivance. *Borelli* hath ſhewn that theſe *Bones* are ſo many *Vectes*, of which the Center of the *Articulation* is the *Fulcrum*, the *Tendons* are the *Ropes*, by which the *Vires Motivæ* of the *Muſcles* elevate, and move any weight, or overcome any Reſiſtence. There is a wonderful, and exactly nice *Geometry* uſed by Nature in the Figure, Connexion, Order, and Motions of theſe *Pillars* of the Body, and of their Cover the *Muſcles*; it were alone a ſufficient work, to ſhew all the *Neceſſities*, the wiſe *Contrivances*, and prudent *adaptations* of theſe admirable *Machines* for the benefit of the whole. I ſhall inſtance only in two or three Particulars, and then proceed. 1. Then, what can be more wonderfully contriv'd than the *Backbone*, had it been all of one entire *Bone*, without *Articulations*, we cou'd not have ſtoop'd or turn'd, but have gone forward like a Poſt or a Pillar; had it been compos'd of a few *Bones* only, then the *Articulations* of theſe *Bones* in bending our Backs, muſt have made a large *Angle* upon their innermoſt edges, and ſo the *Spinal Marrow*, which ſends *Nerves* to all the Inferiour part of the Body, had been in hazard of being bruis'd at every ſtooping; and conſequently all the inferiour Parts, had been in perpetual hazard of being depriv'd of the Inſtruments of their Motions; beſides that the whole wou'd not have been pliable, for the various Poſtures we have occaſion to put our ſelves in. If it had conſiſted of various *Bones* without intervening *Catilages*, we ſhou'd have had no more Benefit by it, than if it had been entire without *Articulations*, or had theſe *Articulations* been after the manner of ſome others of the *Bones*, we had not been capable of theſe Varieties of Motions that we now are, if each *Vertebra* had had its own proper *Cartilage*, the *Articulations* might have been eaſily disjointed. So that we ſee, the Contrivance of this Hulk as it were, of the Body is the beſt that can be imagin'd; for by theſe many and ſmall *Articulations* upon ſomewhat plain and ſmooth Surfaces, ty'd by a common *Cartilage*, the Back for the Security of that *Medullary* Subſtance, that runs down its *Cavity*, is bent after the manner of the *Catenarian Curve*, by which it obtains that *Curvature* that is ſafeſt for the included *Marrow*, and brings the greateſt degree of firmneſs; the oblique Proceſſes of each Superiour and Inferiour *Vertebra*, keeping the middle, from being thruſt backwards or forwards, to hurt the

Spiral

Spinal Marrow. Beſides, had not the *Tranſverſe Proceſſes* been ſo plac'd as they are, to keep the intermediate *Vertebra* from being thruſt backward or forward, then there wou'd have been no more reaſon why in *Inſpiration*, the *Ribs* ſhou'd have mov'd upwards and forwards, than backwards. But as they are now contriv'd, theſe *Proceſſes* force the *Ribs* to move upwards, and ſo lift up the *Sternum*, whence the *dilatation* of the *Thorax* proceeds, which cou'd not *dilate*, were there no *Tranſverſe Proceſſes*, or they otherwiſe diſpos'd. Now can there be a more manifeſt Inſtance of Council and Contrivance than this. Certainly, if infinite Wiſdom were ſuppos'd to have fram'd this part, it cou'd not have giv'n a more pregnant Indication thereof. 2. As I have obſerv'd before, ſome *Bones* are articulated after the manner of *Ball* and *Socket* as the *Humerus* with the *Scapula*, and that for this wiſe End, that the Arm might have all manner of poſſible Motions; but the *Ulna* and *Cubitus* is join'd by way of *Charnal*, that this *Articulation* might be the more ſtrong, for had it been after the former manner, we ſhou'd have had no Benefit thereby, for that *Articulation* of the Shoulder, takes off the Neceſſity of another ſuch here; the Hand by it, having all the Motions, that it could have by another of the ſame kind in this other *Articulation*; and we ſhou'd have loſt the Benefit of the greater Strength in this Joint. Thus we ſee, Nature in theſe Motions loſes no Benefit in the ſeveral Parts, that can conſiſt with the good of the whole. 3. Becauſe the *Tubercles* of the *Bones* of the *Fingers* and *Toes*, cou'd not be conveniently ſo large in Proportion to the middle of theſe *Bones* as they are in others, becauſe thereby in graſping or ſqueezing, theſe points of the *Fingers* which are at the *Articulations*, cou'd only come into *contact* with the Body ſqueez'd, and ſo the Action cou'd not be uniform; and by this ſmalneſs of theſe *Tubercles*, there was a hazard of bringing the direction of the Action of the *Tendons* of thoſe *Muſ-*

cles, which contract the *Finger* and *Toes*, quite through, or very near the *Center* of *Motion*; whereby this Action wou'd have been quite, or almoſt deſtroy'd. Now to prevent this Inconvenience, the *Oſſa Seſamoidœa* (call'd ſo from their Reſemblance to the Grains of *Seſamum*) are plac'd at the *Articulations* of theſe *Bones*, to ſerve as ſo many *Pullies*, about which the *Tendons* paſs, at ſome diſtance from the Center of the *Articulation*, whereby the direction of the Motion of theſe *Tendons*, are remov'd always at the ſame diſtance from the Center of Motion, of the *Articulation*. The ſame Artifice is us'd in the *Knee*, by means of the *Patella*; theſe are wiſe and noble Ends, which the Wit of Men cou'd not have thought of, had they not obſerv'd them.

§ XLIV. How wonderfully is the Brain contriv'd, how carefully and ſtrongly is that principal *Organ* of the Body, fenc'd from external Injuries; by a thick Wall of hard *Bone*, and two very cloſe and compact *Membranes*? What an infinite

Multitude of *Glands*, are in the *Cortical* part; and of begining *Nerves* in the *Medullar* Part, a hundred of which do not exceed one ſingle Hair? How commodiouſly are the *Nerves*, that ſerve for four of the *Senſes*; and all the parts of the *Superiour Regions*, ſent out the ſhorteſt and ſafeſt ways through proper Holes in the Head? And thoſe that ſerve the *Inferiour Regions* of the Body, carry'd down in a *Bony Channel.* And it is very remarkable, that the *Veins* do not paſs out, at the ſame Holes the *Arteries* enter; for if they did, then upon any violent Motion of the Blood, or any greater Quantity thereof than ordinary, log'd in the *Arteries*, their *dilatation* and *pulſation* wou'd compreſs the *Veins* againſt the *bony* ſides of their Paſſage, and ſo occaſion a *ſtagnation* and *extravaſation* of the Blood in the Brain, to the deſtruction of the whole *Machin*; which by theſe different *Entries* and *Exits* of theſe Veſſels is prevented. Theſe *Veins* alſo do not run along by the ſides of the *Arteries* in the Brain, as they

do

do through all the reſt of the Body, which is alſo another wiſe Contrivance of Nature; for the *Arteries* here, were by their *dilatation* to preſs out the Juice from the *Nerves*, into the *Muſcles* of *involuntary* Motion, which wou'd have been hindred if the *Veins* had always gone along with the *Arteries*; for theſe *Veins* wou'd have receiv'd the impulſe of the *Arteries*, and thereby in ſome Meaſure kept it from the *Nerves*. Next how ſtrongly is the *Heart* built, and with what a Force does it ſqueeze out the Blood into the *Arteries*; *Borelli* reckons it equal to the force of 3000 Pound weight, and that 350 Pound weight of Blood, paſſes through the *Heart* ev'ry Hour. How variouſly and effectual for its end, are its *muſcular Fibres* arrang'd, and with what Judgment are its *Columns* and *Furrows* diſpos'd! for the cloſer Contraction of its *Ventricles*; its point is turn'd a little toward the left ſide, for the more eaſie aſcent of the refluent Blood in the *Cava*, for thereby like a reclining inverted *Siphon*, the left *Auricle* becomes lower than the right. All the *Auricles* and *Ventricles* have *Valvs*, whereby the Blood has a paſſage in its true courſe forward, but is hindred from returning the ſame way; which wou'd frequently happen, upon the equal *preſſure* of the Blood on all Hands, and the Reſiſtance of the ſides of the Veſſels, to the Ruin of the *Animal*; which Inconvenience is entirely prevented, by this prudent Contrivance and Situation of the *Valvs*. And ev'n the Figure of the *Valvs* themſelves, in the ſeveral different Places, is for wiſe Ends and Purpoſes. But that which is moſt wonderful in this Affair, is the different *Structure* of the *Heart* in the *Fœtus*, from that of the ſame in adult Perſons. In the Heart of the *Fœtus*, juſt oppoſite to the Mouth of the *Cava aſcendens*, there is a Hole from the *Cava*, that opens into the *Vena Pulmonalis*, and is call'd the *Foramen Ovale*; there is likewiſe a Paſſage, which runs from the *Trunk* of the *Aorta*, to the *Trunk* of *Arteria Pulmonalis*. Now the Blood which is receiv'd by the *Placenta* from the Mother, is by the *umbilical Veins* carried into the *Porta*, from which it is ſent to the *Cava*, by a Canal which goes ſtraight from the *Trunk* of the one, to the *Trunk* of the other, by the *Cava* it is thrown through the *foramen Ovale*, into the *Vena Pulmonalis*, which carries it to the left *Ventricle* of the *Heart*, by which it is ſqueez'd into the *Aorta*, to be diſpers'd over the Body. The Blood that comes from the *Superiour Parts* of the Body, is diverted by the *Iſthmus* of the *Cava* from the *foramen Ovale*, and falls into the right *Ventricle*, which throws it into the *Arteria Pulmonalis*, from whence by the communicating Canal, it is immediately carried into the *Aorta*; ſo that the Blood that comes from the *Cava aſcendens*, paſſes only through the right *Ventricle*, whilſt that which comes from the *Deſcendens*, paſſes only through the left *Ventricle*. The reaſon of which Paſſages, is becauſe the Blood in the *Fœtus* cou'd not go through the *Lungs*, their *Veſicles* by their compreſſure upon the Blood Veſſels, obſtructing that Courſe; neither indeed, did the Blood need to paſs through the *Lungs*, the *Fœtus* being nouriſhed from the Mother, whoſe Fluids had already receiv'd, all the Advantages they cou'd reap from the Air, in her *Lungs*; but when it comes into the *Air*, and is no longer nouriſhed from the Blood of the Mother, this *preſſure* is taken off from the Blood Veſſels, by the diſtenſion of the *Lungs*, after the manner already explain'd. And ſo finding a free Paſſage through the *Lungs*, it runs no more by the communicating Canal: And ſo that dries up; and by the current in the *Pulmonary Vein*, the *Valve* of the *foramen Ovale* is ſhut ſo, that the Blood can no more paſs that way from the *Cava*. Now how wiſely are theſe different Channels for the Blood contriv'd, for the different neceſſities of the *Fœtus*, before and after its Birth! This is a plain Indication of *fore-knowledge*, and of ſuch an one as nothing but Omniſcence, is ſufficient for. And this is certainly one of the moſt convincing Proofs of *Deſign* and *Counſel*, that can poſſibly be wiſh'd for; for to provide for an Event, that in the natural Courſe of things, muſt happen a long time after, is an infallible evidence, that the thing was foreſeen, and the Proviſion deſign'd, by ſome intelligent Being. But this is not the only Inſtance of a *Precaution*, for it's evident, all the ſeveral Steps of the *growth* and *Vegetation*, both of *Animals* and *Plants*, have been foreſeen, and fore-deſign'd, by the wiſe *Author* of *Nature*; ſeeing, different Proviſions are made, and different Circumſtances adjuſted, for theſe various Periods of their Lives.

§ XLV. What a noble piece of *Geometry* is manifeſted in the *Fabrick* of the *Eye*, and the manner of *Viſion!* Without this *Organ*, *Animals* cou'd not provide themſelves with Food, nor be forewarn'd of approaching Danger, and conſequently, cou'd not guard againſt it; without the Benefit of *Light*, the animated part of this *Syſtem*, wou'd be but ſo many *Puppets*, toſs'd up and down by Chance and Fortune, without Houſe or Habitation, and depriv'd of all the Pleaſures and Conveniences of Life. What a miſerable State wou'd it be, to be confin'd to perpetual Darkneſs, and never to behold the chearful Light? the Miſery of ſuch a Life is beyond Expreſſion and Conception: And on the other Hand, what can be more amazing, than that the Particles of Matter ſhou'd be ſo fram'd, as by their means to ſhew us the *Shapes*, *Poſitions*, *Diſtances*, *Motions*, yea and *Colours* of remote Bodies? How wonderfully muſt the ſeveral Coats and Humours of this little *Ball* be diſpos'd, to tranſmit through them that fine, and ſubtile Fluid, which is emitted from *luminous* Bodies, and reflected from the Surfaces of *Opake* ones; and united on the bottom of the *Eye*. Theſe things are not only contriv'd and fram'd with ſo great Wiſdom and Skill, as not to admit of a better; but to any one who attentively conſiders them, they ſeem of ſuch a Nature as ſcarcely to allow any other Method, for it ſeems impoſſible that *Light* ſhou'd repreſent *Objects* to us, at ſo vaſt a diſtance, but by the tranſmiſſion of ſome fine Fluid, from the *Object* upon the *Eye.* And it ſeems impoſſible that any other Compoſition of the *Eye*, ſhou'd be equally fitted for that end. The *Globe* of the *Eye* is *ſpherical*; it is compos'd of ſix *Coats*, and three *Humours*, the firſt *Coat* is call'd the *Conjunctiva*, and makes the white of the *Eye*. The ſecond *Sclerotica*, it is thick, hard, and ſmooth, *Opake* behind, but *Tranſparent* before; where it makes the third Coat call'd the *Cornea*, from its Reſemblance to a piece of *Tranſparent* Horn, it has a greater convexity, than the reſt of the *Globe* of the Eye, conſiſts of ſeveral *Laminæ*, which are nouriſh'd by ſo ſmall Blood Veſſels, as to obſtruct very little of the Light. It is of an exquiſite Senſe, that upon any touch, the Tears might be ſqueez'd from the *Lachrymal Glands*, to waſh and clean it. The fourth *Coat* is the *Choroides*, it lies under the *Sclerotica*, it hath little *Glands* which ſeparate a black Liquor, which *Tinctures* the internal ſide thereof (which is otherwiſe of a whitiſh Colour) for hindring the reflected Light from diſturbing the Pictures of Objects; this Coat has a Hole before, which is called the *Pupilla*, for admitting the Light. The fifth is the *Uvea*, which is nothing but the Circumference of the *Pupilla*; it is compos'd of circular and ſtraight *Fibres*, to contract or dilate, according to the ſtrength or weakneſs of the Light, for when the Light is too ſtrong, the *Circular Fibres* contract the *Pupilla*, that their Force hurt not the *Eye*; and when it is weak, the ſtraight *Fibres* dilate it, to let in more Rays, for the more diſtinct Viſion. On the inſide of the *Uvea* from its *Circumference* which joins the *Choroides*, riſes the *Ligamentum Ciliare*, by which the forepart of the *Eye* is preſs'd outward, and the *Retina* backwad, or the *Axe* of the *Eye* lengthned, at the approach, of too near Objects. The ſixth *Coat* is the *Retina*, which covers like a Net the bottom of the *Eye*, it is only a fine expanſion, of the *Fibres* of the *Optick Nerve*; upon this Coat, the Pictures of Objects are fram'd. The firſt Humour is call'd the *Aqueous*, it lies immediately under the *Cornea*, it is thin and liquid, and of a ſpirituous Nature, in ſo much that it will not freeze in the greateſt Froſt. The ſecond is the *Chryſtalline*, next the *Aqueous*; it is convex on both ſides, and reſembles a double convex *Lens*; it is covered with a fine *Coat*, call'd *Aranea.* The third is the *glaſſy* Humour, it is thicker than the *Aqueous*, and thinner than the *Chryſtalline*, it gives a *Spherical* Figure to the *Eye*, upon its back part, is the *Retina* ſpread, which it keepeth at a diſtance from the *Chryſtalline* Humour, requiſite to receive the diſtinct impreſſion of Objects. The *Optick Nerves* are inſerted in the inſide of the *Optik Axes*, whereby the middle point of ev'ry Object is diſtinctly ſeen, for the Center of the *Retina* is inſenſible, as Monſieur M*ariotte* has ſhewn by Experiment. And conſequently, had the Center of the *Optick Nerves* coincided, with that of the *Retina*, the midle point of any Object, had been inviſible;

viſible; but by this lateral Inſertion of theſe *Nerves*, the point of the Object which is inviſible in the one *Eye*, becomes viſible in the other; for it is impoſſible, that the Rays ſhou'd fall on the inſide of both *Eyes* at the ſame time. The light which comes from the ſeveral points of Objects, is ſo refracted (by the *Cornea* and *Chriſtalline Humour* principally) as to meet again upon the *Retina*, and there to paint in the ſame Order and Proportion, with the Object, the Image thereof, (as is evident by taking off that part of the *Dura Mater*, which covers the backſide of the *Retina*, from the *Eye* of any dead *Animal*, and then placing the *Eye* in a fit Hole, of a dark'ned Room; for looking then upon the back part of the *Retina*, we ſhall ſee through it, the Pictures of external Objects painted upon its inſide) and theſe Pictures propagated by Motion, along the *Optick Nerves*, are the Cauſe of *Viſion*. Now what can be more admirable than this ſtructure of the *Eye*; ev'ry part contributing ſomething toward its Perfection. The

Cornea is more *convex* than any other part of the *Eye*, by which all the Rays are gathered, to paſs through the *Pupilla*, and few of 'em loſt on the *Uvea*. The *Aqueous Humour* being thin, eaſily changes its Figure, either when the *Ligamentum Ciliare* contracts, or both the oblique *Muſcles* protrude, the Bulb of the *Eye*, to render it oblong, when Objects are too near; the *Fibres* of the *Uvea* contract or dilate the *Pupilla*, according to the Degrees of the Strength of the light. The *glaſſy Humour* keeps the *Retina* at a due diſtance from the *Chryſtallin*, the Images are painted upon a Skin, produc'd by the Expanſion of the *Optick Nerves*, for the more eaſie conveyance of the Impreſſion to the Brain. The *Choroides* is tinctur'd black, that the Rays that paſs through it may not be reflected back again upon the *Retina*, and ſo confound the Object. The *Optick Nerves* are inſerted on the inſide of the *Axes* of the *Eye*, that the whole Object may be diſtinctly view'd; the Hairs of the *Eyebrows*, break the direct Rays that they hurt not the ſight; thoſe on the *Eyelids* defend it from filth and light Bodies that ſwim in the *Air*; the continual Motion of *Eyelids*; moiſten and ſweep the *Cornea*, elſe it wou'd dry or grow dirty; it is ſunk in a Hole, wall'd with a ſtrong *Bone*, to keep it from more powerful Injuries. The ſeveral refractive Virtues of the *Coats* and *Humours*, ſerve to correct the Errors ariſing from the different *Refrangibilities* of the Rays of Light. Our Eyes are double, to ſecure both ſides from Danger, becauſe if the Objects were near, however one *Eye* were plac'd, we cou'd not diſtinctly perceive them that ſhou'd be ſituated toward the ſides of our Body, and ſo cou'd not guard our ſelves from the Dangers, thence ariſing. Beſides we cou'd not diſtinguiſh the diſtance of Objects by one *Eye*, for our two *Eyes* are like two different Stations in *Longimetry*, by the aſſiſtance of which, the diſtance between two Objects is meaſured. As alſo, when one *Eye* is accidentally rendred uſeleſs, we enjoy the Bleſſings of this ſo neceſſary a Senſe, by the Benefit of the other. It is obſervable that the Figure of the *Chryſtallin* Humour of Fiſhes, is a great deal nearer to a *Sphere*, than that of Land *Animals*, and that becauſe of the different refractive Vertue of Water from Air, for that convexity which wou'd unite the Rays of Light coming through Air, will not unite the ſame ſo perfectly at a point, in the ſame diſtance, coming through Water. In thoſe *Animals* that gather their Food from the Ground the *Pupill* is *Oval* or *Elliptical*, the greateſt *Diameter* going tranſverſly from ſide to ſide; in thoſe that ſeek their Food on higher Places, its greateſt *Diameter* goes from the top of the Head towards the Feet *perpendicularly*; theſe two different Figures being wonderfully fitted to the different neceſſities of theſe *Animals*. Thoſe living Creatures that by their Figure, and for other reaſons, have no Motions of their Neck, have a Cluſter of *Semiſpherical Eyeballs* which ſend in the Pictures of Objects all around them; and thoſe that ſeek their Food in the dark, have their *Retina* coloured white, which reflects the light and enables them to ſee beſt in the leaſt light; theſe are wonderful and ſurprizing Inſtances, of *Foreſight* and *Counſel* in that Being that fram'd theſe *Organs*; but that which to me is moſt ſurprizing in this Affair, is that in rational Creatures, whoſe *Organs* are ſound; they ſhou'd have been ſo nicely fram'd in all the infinite poſſible Varieties over and under, as to repreſent Objects at a due Diſtance of their true and real *Magnitudes*, and this we are certain of by our other Senſes, which all concur to demonſtrate that Objects at a due Diſtance, are of the ſame real *Magnitude* our *Eyes* repreſent them. Now we know from the Laws of *Opticks*, that had the *Retina* been remov'd farther from, or brought nearer the *Chriſtallin* Humor, or (keeping the *Retina* at the ſame Diſtance from that Humor) had it conſiſted of two *Segments* of a leſs or greater *Sphere*, the Viſion had been indiſtinct or none at all; or had the Diſtance been fitted exactly in the *Focus* of the *Chriſtallin*, but had it conſiſted of of *Segments* of *Spheres*, leſs or greater, than thoſe of our *Chriſtallin Humour*, that are at preſent, we had ſeen Objects ev'n at a due Diſtance, either bigger or leſs than the Truth, which wou'd have expos'd us to a thouſand dangerous Miſtakes; for Example, the Precipice that perhaps was not many Feet from us, might have appear'd at ſome Paces Diſtance, and we have tumbled down, ere we were aware, or the *Atom* that we now ſcarce take Notice of, wou'd have covered all our View, and hindered us from taking in any other Object; in a word, beſides that thus we ſhou'd not have diſcovered the true *Magnitude* of Objects, which wou'd have had a thouſand fatal Conſequences, had our Eyes magnified Objects, any thing conſiderably, we cou'd have ſeen but a very ſmall part of them at once, and twenty dangerous things might have been in our ways, which we cou'd not have diſcovered, but by a great deal of Pains; ſo that our Progreſſive Motions, muſt have been ſlower than thoſe of *Reptils*, and then ev'ry little Particle, likewiſe, wou'd have been able to have damn'd up, and obſtructed our Sight; and had our *Eyes* diminiſhed Objects conſiderably, we cou'd have ſeen them but faintly and indiſtinctly, all minute Bodies wou'd have vaniſhed, and we might have been deſtroy'd by thoſe which we thought at a diſtance. In one Word, there are Infinities of different Ways, our *Eyes* might have poſſibly been form'd, none of which cou'd have brought with it, the Advantages the preſent Structure does. Can there then be a more pregnant and convincing Evidence of the *Being* of an *infinitely wiſe* Power, who out of the infinite poſſible Varieties, of diſadvantagious Fabricks of this *Organ*, has ſingled out that only one, that was beſt; he certainly deſerves not to enjoy the Bleſſings of his *Eye Sight*, whoſe Mind is ſo deprav'd, as not to acknowledge the Bounty and Wiſdom of the Author of his Nature, in the *raviſhing* and *aſtoniſhing* Structure of this noble *Organ*.

§ XLVI. *Hearing* is the next Senſe in Dignity to *Seeing*, (for I reckon *Feeling* a general one, of which the reſt are only particular *Modifications*) without which our Lives wou'd be very Comfortleſs. It is by Means of this Senſe, we enjoy the Benefits of Converſation, and the Pleaſures of *Muſick*; and by it we are forewarn'd of thoſe Dangers, our Eyes cannot inform us of; and what can be more wonderful than that the ſame *Medium* of Air, ſhou'd ſerve us for ſo many different, yet neceſſary Uſes: By it our Vapours are ſupported, and buoy'd up to the higher Regions, to be there form'd into Snow or Rain, according to the Exigences of different *Climates*; by it's Motion our Winds are produc'd, which ſail our Ships, and purifie our *Atmoſphere*; by drawing it in we live, and our Blood is fitted to perform its *Circulations*; by it Sounds are convey'd to our

Ears, and other Mens Thoughts to our Minds. The Internal Parts of the *Ear* are theſe, 1. The *Meatus Auditorius*, which is a contorted Paſſage for the outward Air, runing firſt upward, and then downward; here are many *Glands*, which ſeparate a viſcid glutinous Matter, which hinders Inſects, or any hurtful thing, from corroding the *Tympanum*, which is a ſecond principal Part of the internal *Ear*. It is a thin *Membrane*, like the Head of a Drum, ſtretch'd upon a Bony Circle, behind which is the *Barrel*, in the Cavity of which there are four little Bones call'd the *Hammer*, the *Anvil*, the *Stirrup*, and the *Os orbiculare*. In this *Barrel* there are ſeveral Holes, one of which opens, behinds the Palate of the Mouth, and receives Air to ſupply theſe Cavities, that have no Communication with the Air, coming in by the outward *Ear*. Next to the *Barrel*, is the *Labyrinth*, which ends in the *Veſtibulum*, and is follow'd by the *Cochlea*, which is a Paſſage reſembling a *Snail's Shell*, in it the Auditory *Nerves* terminate. Now when any Sound is propagated in *Undulations* through the Air (the *Sonorous* Body ſtriking the Ambient, Air by many repeated *Vibrations*, excites theſe *undulations* in it, after the manner any heavy Body thrown into a ſtanding Lake, raiſes in the Water, Waves in a Circle round it) theſe are gathered by the *Concha*, or external *Ear*, and carried through the *Meatus Auditorius*, to the *Tympanum* or Drum, on which beating, the four little Bones that are in the *Barrel*, are thereby mov'd; and as the Drum is ſtruck by the external Air, after the ſame manner is the internal Air mov'd by theſe little Bones; and this internal Air, thus mov'd, makes an Impreſſion upon the *Auditory Nerves*, in the *Labyrinth* and *Cochlea*; ſo that as the external Air ſtrikes the *Drum*, ſo does it move the Bones in the *Barrel*, to ſtrike the internal Air after the ſame manner; and as it is mov'd, ſo accordingly is the Impreſſion made upon the *Auditory Nerves*, and all this *Apparatus* ſeems intended, to hinder the Sound from coming with too great Violence upon theſe *Nerves*, for we find that too ſudden, and violent a Noiſe, is ſtill able to diſturb theſe ſlender *Tubes*, and ſometimes to diſorder them ſo, as to deprive us of this *Senſe*. Now how wiſely is this neceſſary and pleaſant *Senſe* contriv'd, for the Conveniences of Life! Had it been more exquiſite, then every little Noiſe had been capable of diſturbing us, the buzzing of a Flie, or the Noiſe of our own Breath, wou'd have pirc'd our *Ears* like a Peal of Thunder, and the Motion of every little *Atom* wou'd have rob'd us of Reſt; and had this *Senſe* been any thing conſiderably more dull, we ſhou'd have been in proportion thereto, depriv'd of all the Pleaſures and Advantages thence ariſing: ſo that it's evident our *Hearing*, is nicely adjuſted to the Conveniencies and Neceſſities of Life, which is a plain Inſtance of *Deſign* in the Fabrick of this *Organ*; the ſame might be demonſtrated of the two remaining Senſes, which for Brevities ſake I muſt now omit.

§ XLVII. I have before obſerv'd, that all the Canals except the *Arteries* have *Valves*, by which their Fluids are permitted to go forward, in their Courſe, but hindered from returning back, all theſe *Valves*, opening toward the term of the Natural Motion, of theſe Fluids, but ſhuting by the Preſſure of the Blood in a contrary Direction, and thereby obſtructing that backward Motion. Theſe *Valves* are viſible, not only in the *Veins* but in the *Lymphaticks*, the *Lacteals* and *Ductus Thoracicus*; and it is obſervable that this laſt *Channel* always goes up the left ſide, that by the Pulſation of the great *Artery*, upon which it immediately lyes, the *Chyle* may be propell'd upward. It is likewiſe remarkable, that all the Branches of the *Arteries* which go off, at any ſmall Diſtance from the *Trunks*, do all unite again in one *Trunk*, whoſe Branches communicate with one another, and with others, as before; and that for this wiſe End, that when any ſmall *Artery* is obſtructed, or cut, the Blood may be brought by the communicating Branches, to the Parts below the Obſtruction, which muſt have otherwiſe been depriv'd of Nouriſhment. The *Velocity* of the *Blood* in the extreme *Arteries* is conſiderably leſs, than that of the ſame at the *Heart*, or its Entry into the *Aorta*, becauſe it is of theſe extreme *Arteries* the *Glands* are form'd, and by them the ſecretions are made, which as was before demonſtrated, require different *Velocities* in the Blood, to ſecern the different *Fluids* in theſe *Glands*: this Diminution of the *Velocity* is evident from the Proportions Dr. *Keill*, (to whoſe Accurate *Compendium*, of the *Anatomy* of *Human Bodies*, I have always had recourſe, where my Memory fail'd me) has giv'n us all the Branches of the *Arteries* to the gteat Trunk, whereby it appears the *Diameter* of the *Aorta*, does not bear a greater Proportion, to the primary Branches of the *Arteries*, than 5 to 7: and doubtleſs the odds is greater in the ſmaller Branches. How frugal has Nature been in the Structure of the

Veins! for becauſe of the leſs Preſſure of the *Blood*, againſt the ſides of theſe widening Channels, the thickneſs of their Walls is in proportion leſs, than thoſe of the *Arteries*. Beſides, that only thoſe *Veins* that run *perpendicular* to the *Horizon*, are endow'd with *Valves*, which ſtick to their Sides like ſo many Thimbles; which when the Blood preſſes back, are fill'd, and ſo ſtop its Paſſage, but are compreſ'd by the foreward Motion of the Blood. Now theſe *Valves* were uſeleſs in other *Veins*, for their widening Channels, give no Occaſion to the Blood to puſh backward, it's Gravity acting laterally and not backward, as in thoſe *perpendicular* to the *Horizon*; the ſmall Branches of theſe *Veins*, communicate with one another, for the ſame ends and purpoſes that the *Arteries* did; and having now Occaſion to ſpeak of the containing Veſſels, I cannot omit here the wonderful Contrivance of Nature in the Poſition of the ſeveral Parts of the *Fœtus* in the *Uterus*; the *Skull* whereof in the firſt part of the time of its *Geſtation* being very thin, large and only *Membranous*, the *Thorax* and *Abdomen* with the Limbs are ſo diſpos'd as to make the Head always emerge out of the Fluid it lies in, or at leaſt preſerves it in a Direction that it is ſtill upward, with its Face to toward it's Mothers Belly, but about the time of its Delivery the Skull thickens, and hardens, the Limbs and Members ſtretch out, and ſo the Head becomes the heavieſt place in the Body whereby it tumbles over, and acquires that Poſture which is fitteſt for its Delivery. Theſe are ſignal Inſtances of Counſel and Foreſight, in the Formation of theſe *Organs* and parts, but I haſten to a Cloſe.

§ XLVIII. Having I think ſufficiently made out that great Truth, to wit that we are *wonderfully made*, though I have pointed only at a few of thoſe Inſtances that the *Animal* Fabrick and *Oeconomy* affords, I now come to make a few general Obſervations under one Head, and ſo to put a Cloſe to this *Chapter*, which has already ſwell'd to a far greater

Bulk than I at firſt deſign'd it. It is very remarkable, that thoſe *Animals*, *Plants*, and *Minerals*, that are of moſt Uſe, and Advantage to us, are ſuch as will grow almoſt in every *Soil* and *Climate*, and are more productive of their kind than others, and are found in moſt Places. Thus *Iron* is is found almoſt every where, *Corn* is the Product of all Soils, and *Climates*, while other more curious and nice *Plants* will only thrive in their proper Soils: Thus *Hens*, *Geeſe*, and *Turkies* are more productive than *Crows* or *Jackdaws*, and *Conies*, and *Hares*, than *Foxes* or *Lyons*; thus a *Crane*, which is but ſcurvy Meat, lays but two Eggs, and the *Alka* and ſome other Sea Fowls, but one, whereas the *Patridge* and the *Pheaſant* hath fifteen or twenty, and thoſe which lay fewer, and are of moſt value for Food, lay oftner, as the *Woodcok* and the *Dove*. What is more admirable, than the fitneſs of ev'ry Creature for the uſe we make of him? The *docility* of the *Elephant*, ſo long employed in War, the *Inſitiency* of the *Camel*, for travelling in the parch'd and dry Deſerts, the gentleneſs of the Sheep, the Cleanneſs, Beauty, Strength, and Swiftneſs of the Horſe, whoſe Breath, Foam, and ev'n Excrements are ſweet, and thereby ſo well fitted for our Uſe and Service! How frugally has Nature avoided any uſeleſs Expence of *Organs*, when the Circumſtances of the *Animal* wou'd have rendred 'em ſo? Thus thoſe *Animals* that are ſlow of their Nature, have no very quick ſight, it being uſeleſs to ſuch, ſince their ſlowneſs allows them time to dwell longer on an Object, as *Snails* and *Moles*; but theſe that are endow'd with a quicker Motion, have brisker Eyes, and a more quick piercing ſight, as *Hawks* and *Hares*. Thoſe *Animals* alſo, that have no Ears have no *Organs* for making a noiſe with; becauſe wanting Ears, theſe other wou'd be uſeleſs, as *Fiſhes* and other Inhabitants of the watery *Element*. So alſo, thoſe *Animals* which have Teeth on both Jaws, have but one Stomach, becauſe theſe Teeth render more Stomachs uſeleſs; and thoſe *Animals* that have no upper Teeth or none at all, have three Stomachs to ſupply the want of theſe Teeth; as in Beaſts, the *Panch*, the *Read* and the *Feck*; and in all granivorous Birds, the *Crop*, the *Echinus* and the *Gizzard*. A Man which has a bigger Brain in proportion to his Body than any other *Animal*, has a better and more eaſily manageable Hand; whereas a *Monkie* that has little Brains, and conſequently can have no great Uſe for much dexterity, has not ſo well a ſhap'd nor eaſily applicable a Hand. Theſe, and a thouſand ſuch Inſtances of *Wiſdom*, *Counſel*, and *Meliority* in the Contrivance and Fabrick of the ſeveral *Animals*, may be gathered by any one who will conſult the Writings of natural Hiſtorians. But thoſe who will not be convinc'd by the Inſtances I have brought that there is a God who rules *in the Kingdoms of the Earth*, who number'd all our parts, and appointed them out their ſeveral Ends and Uſes, I am afraid will not be prevail'd upon by thoſe behind.

Chap. IV.

Of the Nature of Finiteneſs and Infiniteneſs, and the Limits of Human Knowledge.

§ I. IT is beyond all Diſpute, that our Minds and Capacities, are as really bounded and circumſcrib'd, as our Bodies; and that it is as impoſſible for us to extend our Intellectual Faculties, beyond their determin'd Limits, as it is for us to add a Cubit to our *Stature*; There are ſome things, that we can never by all our Endeavour, attain to a perfect Comprehenſion of; in vain we Labour, in vain we Struggle, the Eyes of our Underſtanding are capable of but a limited *aperture*, and of receiving but a bounded Object; If we ſtrive to enlarge it, we perceive nothing, but Darkneſs and Confuſion: We may ſooner be able to *accommodate* a Line of ten Feet, in a Circle of a Foot *Diameter*, than be able to conceive, how ſome things can be, whoſe Exiſtence notwithſtanding, we are forced to allow; and ſince it is ſo, it becomes a Wiſe Man to diſtinguiſh between what he can really underſtand, and comprehend, and where he muſt be contented to be ignorant.

§ II. *Magnitude* or *Quantity* in the *Abſtract*, is that of which we have the cleareſt and juſteſt Apprehenſions, as it is evident from hence, that almoſt all Men, who have apply'd themſelves diligently to diſcover, in a proper Method, the Properties of *Lines*, *Figures* and *Numbers*, have agreed in their Concluſions: The Reaſon of which is, that the *Notions* and *Ideas*, of theſe things, are both the ſimpleſt, leaſt compounded, and moſt diſtinct, and have the leaſt Influence on our Paſſions, Prejudices and Intereſts, which generally give the *Byaſs*, to our Reaſonings; and yet for all this, our Minds can never conceive nor our Imaginations form an *Idea* of an unlimited or boundleſs Quantity. We may indeed improve either of theſe *Faculties*, by Study and Induſtry ſo far, as to be able to reach Heights that may ſeem ſurpriſing to thoſe that do not apply themſelves to ſuch Matters; but ſtill there are ſome things, to which we can never attain, there is a *Non plus ultra*, beyond which all is *palpable Darkneſs*, and *profound Obſcurity*.

§ III. We may call *finite*, that whoſe *Bounds* or *Limits* are given; or that which is bounded on all poſſible ſides; *infinite* that which is bounded or limited no way; thus a *finite* right Line is that, both whoſe Extremities are determin'd or given. An *indefinite* right Line, that, one of whoſe Extremities is given, but not the other; *i. e.* a right Line with but one Extremity. An *infinite* right Line, that which is both ways *ndefinite*, *i. e.* a Line with no Extremity at all. Thus an *equilateral Triangle*, or a *Circle* of a given ſide or *Radius*, comprehends a given or *finite Area*; but of an *infinite* ſide or *Radius*, (if one may be allow'd to ſpeak ſo) an *infinite Area*, as alſo an *equilateral Cone*, or *Sphere*, of a given ſide or *Radius*, makes a *finite* Solid; but of an *infinite* ſide or *Radius*, an *infinite* Solid. But becauſe *Infiniteneſs* is of that Nature, that it neither can be defin'd by us, from its *poſitive* Properties, nor apprehended, by its *eſſential* Attributes, we are forced to deſcribe it, by telling what it is not, rather than what it is. And ſeeing before we can ſpeak any thing diſtinctly a bout the Nature of *Finiteneſs* or *Infiniteneſs*, we muſt have ſome Mark or Rule, to diſtinguiſh the one from the other, there is none, I think, more certain, than this, that *infinite* is always greater than any *finite* Quantity, how great ſoever; for whatever Quantity always exceeds, all poſſible Degrees of *Finites*, how great ſoever, muſt be *Infinite*, ſince we can have no Notion of any real Quantity but *Finite* and *Infinite* with the Degrees thereof.

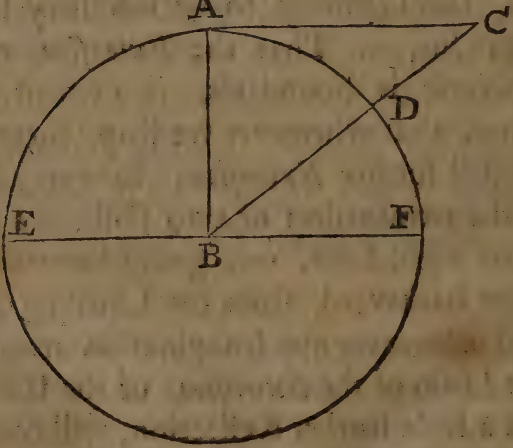
§ IV. There are two Kinds of *Infinits*, or *infinitely* great Quantities; one *Relative*, which is only *Infinite*, in reſpect of another Quantity, infinitely Leſs: and of theſe there are Gradations *in infinitum*, each of which, tho' infinitely Little, in themſelves, is yet infinitely Great, in reſpect of thoſe infinitely Leſs. Thus any right lin'd *Angle*, is *infinite* in reſpect of the circular Angle of *Contact*; And there are other *Curves in infinitum*, whoſe *Angles* of *Contact* are *infinitely* Leſs, than circular ones, as we ſhall afterwards demonſtrate. Thus in the Motions of the *Planets*, the *Centripetal* Force, in *infinitely ſmall Portions* of their *Orbits*, is infinitely Little, in reſpect of the *projectile* Force, or this is infinitely Great, in reſpect of that. The other *Abſolute*, which is *infinite*, in reſpect of any *finite* Quantity, how great ſoever: thus the Space contain'd between the *Aſymptote* of ſome *Hyperboloids*, and a Line *parallel* thereto, at a *finite* Diſtance from it, is *infinite* in reſpect of the *finite* Space, of an *infinite* Length, comprehended between the *Aſymptote* and the *Curve.* Thus the *Expanſion* or Space of the Univerſe, is *infinite*, in reſpect of the place of Body. And what is ſaid of *infinitely* great Quantities, is alſo true of *infinitely* Small ones, for if an *infinitely* ſmall Quantity, may be a Relative *infinitely* Great one, in reſpect of an *infinitely* Leſs. *Infinitely* Small, and *infinitely* Great, will then become correlatives, and conſequently the ſame may be *infinitely* Great, and *infinitely* Small, in reſpect of other *infinitely* Greater, or Smaller, and therefore Univerſally, as *infinitely* Great, is to *finite*, ſo is *finite* to an *infinitely* ſmall Part thereof, as alſo, as *finite* to an *infinitely* ſmall Part thereof, ſo is that, to an *infinitely* ſmall Part of this *infinitely* ſmall one.

§ V. *Numbers*, are the moſt ſimple and diſtinct *Pictures*, or *Repreſentations*, of *finite* Quantities, and conſequently they would be ſo likewiſe of *infinite* ones, if an *infinite Number* were aſſignable ; But ſeeing ſuch a thing, is impoſſible, we muſt conſider how any *finite* determin'd *Number*, is increas'd or diminiſh'd, and go on in increaſing, or diminiſhing *in infinitum*, and thus frame our Notions of *infinitely* great or *ſmall Numbers*; Thus, if we add *unity* perpetually to itſelf, we ſhall have as great a *finite Number* as we deſire, and if we continue thus adding *in infinitum*, we ſhall at laſt have a *Number* greater than any *finite* one, how great ſoever; *i. e.* we ſhall have an *infinite Number*, not actually, becauſe we can never actually go thro' theſe *infinite* Additions; But Virtually, *i. e.* we ſhall have the Progreſſion, or the Repreſentation of the Nature, of ſuch a *Number*, whoſe Sum at laſt would be equal to an *infinite Number* of Unities, or other *finite Numbers*. And becauſe a conſtant Addition, ſo many times, of a determin'd *Number*, is equivalent to a Multiplication of ſuch a *Number*, by ſuch another *Number*, therefore what may be had by a perpetual Addition, may be more eaſily obtained, by ſome one or more Multiplications, join'd together. Likewiſe, as by a perpetual Subtraction, from any *finite Number* how Great ſoever, of one or more unites, we ſhall at laſt obtain a remainder, equal to any finite Number, how ſmall ſoever, ſo by ſuch a Subtraction perpetuated *in infinitum*, we ſhould obtain a *Number*, ſmaller then any *finite Number*, how ſmall ſoever, *i. e.* an *infinitely* ſmall *Number*. And becauſe Diviſion is only a perpetual Subtraction of ſuch a *Number*, ſo many times as the Diviſor implies, therefore, whatever may be obtained in this Caſe by Subtraction, may be alſo had by Diviſion. But here it is to be obſerv'd, that the whole Force of this manner of generating an *infinitely* great or ſmall *Number*, lies in the *infinitely* perpetuated arithmetical Operations, upon finite given *Numbers*; not that theſe Operations, in any finite time, can actually compleat or exhibit the *infinite Number* required. But that theſe continued *in infinitum*, would at laſt exhibit them, if ſuch a thing were to be obtain'd.

§ VI. That *infiniteneſs* implies no Contradiction, in its Import or Signification, (as ſome have thought) is evident from both the ways juſt now mentioned, of generating an *infinitely* great or ſmall *Number*, which may repreſent any *infinitely* great or ſmall Quantity whatſoever; for whatſoever has once been, implies no Contradiction it ſhould be again, and if a *finite Number*, or Quantity may be once added to itſelf, it may be again added to itſelf, and again, and a third time, and conſequently it implies no Contradiction it ſhould go on conſtantly, in being added to itſelf, *in infinitum*; and the Sum of all theſe, would make a Number greater than any *finite Number*, how great ſoever; *i. e.* an *infinite Number.* Again, if you can multiply a *Number* by itſelf, you may do it again, and again, at leaſt it implies no Contradiction, it ſhould be ſo multiply'd; and after an aſſignable *Number* of ſuch Multiplications, it may be ſtill multiply'd by itſelf, or another *Number*; and ſo it implies no Contradiction, it ſhould be ſtill going on in Multiplying; the Product of all which Multiplications, and the Sum of all which Products, would make a *Number* greater then any *finite* one, how great ſoever, *i. e.* an *infinite Number.* Likewiſe it's certain that between any two given Terms an *infinite* Number, of *Geometrical* mean Proportionals, can imply no Contradiction, ſince we can aſſign their Sum; thus betwixt $\frac{1}{2}$ and 0 the Sum of an infinite Number of mean *Proportionals*, at the rate of 2 to 1 is equal to Unity; and ſince the Sum is aſſignable, the Parts can imply no Contradiction; and univerſally betwixt $\frac{1}{a}$ and 0, there and an infinite Number of mean *Proportionals*, in the *ratio* of *a* to 1, whoſe Sum is $\frac{1}{a-1}$, and the mean *Proportionals* themſelves, are $\frac{1}{a}$, $\frac{1}{a^2}$, $\frac{1}{a^3}$, *&c.* Beſides, the whole *abſtract Geometry*, depends upon the poſſibility of *infinitely* great, and ſmall Quantities, and the Truth's diſcover'd by *Methods*, which depend upon theſe Suppoſitions,

poſitions, are confirm'd by other *Methods*, which have other Foundations; and they are too well ſupported, to allow of any Heſitation, in thoſe that are throughly acquainted with this Science. Inſtances are needleſs, ſince whoever does underſtand theſe things, need not be told this.

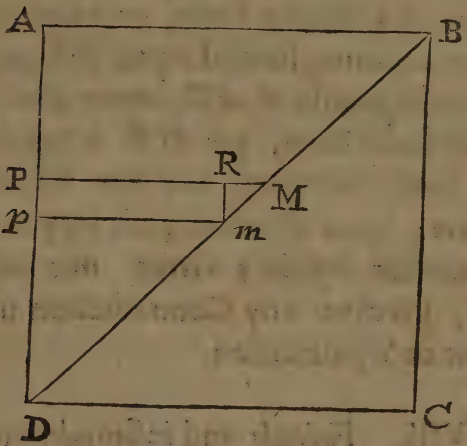
§ VII. But that *Infiniteneſs*, involves no Contradiction in its Import or Signification, is evident from the neceſſity of allowing both *Extenſion* and *Duration* to be boundleſs, and Quantity to be infinitely Diviſible; for, 1. That the *Extenſion*, of the Univerſe is boundleſs, is evident from hence, that whereever we ſtop, there muſt be ſtill further *Extenſion*; for every Limit is the termination of two Diſtances in the ſame right Line, one going forward, the other backward, from the Limiting Point, and whereever our Imagination may place the *Limits* of the *Extenſion*, of the Univerſe, yet a little further Reflection, will convince us, there muſt be *Extenſion* beyond theſe *Limits*, for in *Extenſion*, the end of one Part of it, is the beginning of another, and ſo it muſt go on without Bounds or Limits. Moreover, if the *Extenſion* of the Univerſe is *finite* only, then a *Sphere* of a finite *Diameter*, may be found equal to it, for a *Cube* of a *finite* ſide, may be found equal to any finite Content whatſoever, as is well known; and the *Radius* of a *Sphere* equal to this *Cube*, is the Product of the ſide of the *Cube* multiply'd, into the *Cube Root* of $\frac{3}{2}$ parts of the *ratio* of the *Radius* to the *Circumference*.



Let us then ſuppoſe the whole finite *Extenſion* of the Univerſe, equal to the *Sphere*,

Sphere, whoſe *Radius* is *A B*, let this *Sphere* be cut by a plane through its Center, and the Section, be the *Circle A D F E*; it's certain from the *Elements* of *Euclid*, that to any given Point *A*, a *Tangent A C*, may be drawn, of which only the Point *A* falls upon the *Circle*, the reſt falling without it; from whence it's evident, that there muſt be *Extenſion* without this Circle, or the *Sphere* by the Section of which it is generated; ſince a plane paſſing through this *Tangent*, will only touch the *Sphere* in the Point *A*, by which there will an extended Diſtance remain, between the *Circumference* of the *Sphere* and the *Tangent* in all their Points excepting one, and ſince this is true, of every finite *Extenſion* how great ſoever, it's evident the *Extenſion* of the Univerſe is greater than any finite *Extenſion*. 2. As to *Duration*, it is evident, that it both has been without a beginning, and muſt be without an end, for whether this Univerſe had a beginning or not, yet time or *Duration* muſt have for ever been; there is an abſolute neceſſity, of admitting ſome real Being to have been for ever, as I have already demonſtrated, in the preceding Chapters; and conſequently the *Duration* of this Being, has been for ever; and ſince ſome real thing muſt for ever *exiſt*, therefore the Duration of this thing muſt for ever be; ſo that it's evident, whatever *Scheme* of *Philoſophy* we go upon, *Duration* muſt be *infinite* both *à parte ante*, *& poſt*, as the Schools ſpeak. Beſides, were there nothing actually exiſting, yet time could not be ſaid not to exiſt, for we cannot ſuppoſe a time, when time was not, the very Suppoſition, deſtroying itſelf, wherefore *Time* or *Duration*, is, and muſt be *infinite*. 3. The infinite *Diviſibility* of Quantity is ſo plain, and demonſtrated from ſo many different Principles, that it were needleſs to dwell upon it, the moſt perfect and unavoidable Proof thereof, is the common one, from the *incommenſurability*

menſurability of ſurd Quantities, let *ABCD* be a *Square*, whoſe *Diagonal* is *BD*, then



is the ſide *AD* to the *Diagonal BD*, as 1. $\sqrt{2}$. from whence it's plain, that dividing the ſide *AD* into Parts equal, how ſmall ſoever *Pp*, yet ſtill *Pp* or *Rm* ſhall be to *Mm*, as 1 to $\sqrt{2}$. Since the *Triangles ABD*, *RMm* are *Similar*, ſo that is impoſſible before an actual infinite Diviſion of the ſide *AD*, to find a Part in the *Diagonal Mm*, that ſhould have to *Pp*, any ſuch Proportion as either *Integers*, or *Fractions* have to one another, *i. e.* it is abſolutely impoſſible before an actual *infinite* Diviſion, to find a part *P p* in the ſide *A D*, that taken a certain finite, or even infinite Nunber of times, ſhould equal *DB* exactly, and conſequently if *A D*, were divided in ever ſo ſmall Parts, yet *B D* is capable of being further divided, and that ſtill on, *in infinitum*; from all which, it's very evident, that neither *infinitely* Great, nor *infinitely* Small, involves any Contradiction in their Import or Signification.

§ VIII. *Finitude* and *infinitude*, involve nothing in their Import and Conception, but the Degrees of the Properties of Things; they do not ſignifie really Beings, or Things in themſelves, but the *Modes*, and Meaſures of the *Affections* of Things; *Infiniteneſs* is an *abſtract Term*, ſignifying the unboundedneſs of the Property, or Quality of a real Being, but like all other *Adjuncts*, does not imply a real *Idea*, till it is joyn'd to ſome *Subſtantive*; thus *infinite*

finite Knowledge, or *infinite Wiſdom*, unlimited *Extenſion*, and endleſs *Duration*, are intelligible Properties of things, but *Infinity* is a *vague* and undetermin'd Notion, till its Import is determin'd by the Addition of a proper *Subject*; ſome Perſons have thought that *Infinitneſs* was a contradictory Term, becauſe they could not comprehend its Extent, or paint an Image thereof upon their Imaginations; others have thought, that nothing could be capable of having *Infinity* aſcribed to it, but immediately it muſt belong to the firſt Being, and ſo could not belong to a Creature, becauſe whatever was *infinite* in any one Property, they thought muſt neceſſarily be ſo in ſeveral others, which deſtroyed the Nature of a created Being. The falſity of the firſt, I have ſhewn in the two former *Sections*, and tho' I am of Opinion, that there is no *Creature*, endowed with any Quality, infinite in Degree; yet certain it is, that there is no abſurdity, that there ſhould be ſuch, ſince there may be *infinites* of ſeveral Kinds, which may have no Relation to, nor Dependance upon one another: Thus a *Line* may be limited at one Extremity, but unlimited at the other, a *Parallelogram* may be of an *infinite* Length, but of a *finite* Breadth, and a Solid may have *infinite* Length, and Breadth, but a *finite* Thickneſs or Profundity; thus alſo the *Extenſion* of the Univerſe, or the *mundan Space*, may be boundleſs, and yet have no other real Property; and Time, or *Duration*, may be *eternal*, and have neither Knowledge, nor Wiſdom; ſome Properties involve ſome others neceſſarily, as Solidity does Impenetrability, ſome do not at all imply others, as *Extenſion* does no way imply Thought, nor Motion, Knowledge; and when a finite Degree of any one Property, implies a finite Degree of another, the *infinite* implies the *infinite*; but when a *finite* Degree of any one Property, does not at all imply any Degree of another, the *infinite* Degree of that Property, does not at all alter the former Caſe, nor imply any Degree of that other, either *finite* or *infinite*: Wherefore there is no Impoſſibility, or Abſurdity, that a created Being ſhould be endowed with ſome Qualities *infinite* in their Degree, provided theſe do not imply others which deſtroy the Eſſence of a Creature; And this Univerſe may be a created Being, and yet be *infinite* in its *Extenſion*, ſince *Extenſion* implies neither Knowledge nor Reflexion, nor any of the Properties of ſpiritual Beings; As alſo this World may have been from all *Eternity*, and yet have been created, for eternal Duration implies no other poſitive Quality, unleſs we ſuppoſe it to have been from all *Eternity of it ſelf*, which quite alters the Caſe; for the neceſſary Exiſtence of a thing from *it ſelf*, implies many other Qualities, as I have ſhewn in the laſt *Article* of the *ſecond Chapter*; but in effect, *Time* and *Space*, are no real things, nor compleat Subſiſtences, they are only the *Modes* and *Circumſtances* of other things. I do not here detemine, whether *infinite Extenſion*, and *eternal Duration*, may be the *Immenſity* and *Eternity* of that firſt great Being, which is endow'd with all other ſuitable Qualities, tho' perhaps, there may be abundance of Reaſon to lead one to think ſo; all I maintain, is, that there is no Abſurdity in admitting Creatures to be endow'd with ſome Qualities, *infinite* in their Degrees, which do not neceſſarily involve thoſe others, that deſtroy the Being of a Creature.

§ IX. *Finites* and *Infinites* are *Diſparata*, or things of a quite different Nature, like *Light* and *Sound*, *Colours* and *Muſick*, *Extenſion* and *Thought*, they have few or no common Qualities, and very many quite contrary ones; *finite* is bounded, *infinite* boundleſs, *finite* conceivable, *infinite* incomprehenſible, *finite* exhauſtible, *infinite* inexhauſtible, no *finite* Addition nor Multiplication of *finites*, can produce an *infinite*, nor has *finite* to *infinite* any aſſignable Proportion, for theſe only have a Proportion to one another, which by finite Multiplications, can mutually exceed one another; from whence it is evident, that *finite* is no part of *infinite*, and that *finite* can neither be added to, nor ſubſtracted from *infinite*, for only theſe things that are of the ſame kind are capable of Addition, or Subtraction, you cannot add *Cows* to *Horſes*, becauſe no Number, nor part of the one, can make the other, ſo likewiſe you cannot add *finites* to, nor ſubtract 'em from *infinites*, becauſe no *finite* Number of *finites*, can make an *infinite*, nor any *finite* part of an *infinite* make a *finite*, wherefore in the *Arithmetick* of the one, the other is to be neglected, as no parts of the *Quæſitum*; ſo likewiſe in the *Arithmetick* of *finites*, all *infinites* are to be thrown away, as no parts of the thing we ſearch for. The ſame is true, of any *infinitely* great or little Quantity, of a higher Rank, in reſpect of thoſe of a lower, for when the Proportion between any kinds of *infinites*, (either *infinitely* Great or *infinitely* Small) is the ſame, as that between an *infinite* of the loweſt kind and a *finite*, then in the *Arithmetick* of ſuch *infinites*, the lower is to be rejected, in the *Arithmetick* of the higher kind; thus the ſquare Root, of an *infinite* Quantity, is to be thrown away, in the *Arithmetick* of the Squares of *infinite* Quantities; and the Squares, in that of the *Cubes*, and ſo in the higer Powers. But in *infinitely* ſmall Quantities, the contrary obtains, by reaſon that the Product of the Multiplication of two Fractions, is always leſs than either of the Factors. But whereever the Proportion of *finite* to *infinite* obtains, the laſt is always to be rejected in the *Arithmetical* Operations of the firſt, becauſe no *finite* Multiplication of the latter, can produce the former, and therefore this is no Part of that, I mean in *Arithmetical* Operations, of Addition and Subtraction of theſe Quantities.

§ X. The poſitive Nature of *Infinites*, is abſolutely incomprehenſible, by *finite* Capacities, ſuch as ours are; both our Imaginations and Apprehenſions are *finite*, ſo we can neither frame a Picture to ourſelves, nor form a Notion of *Infinity*; our Memories and our diſcurſive Faculties, are limited, ſo we can neither exhauſt the Contents, nor run over the Parts of *Infinites*, in a word, by none of the *Faculties*, nor any of the *Operations* of the Mind, can we attain to the poſitive Properties, or eſſential Attributes of *Infinites*. We ſee for Exemple in Numbers (the moſt adequate Pictures of all finite Quantities) that a diſtinct Apprehenſion, of their poſitive Qualities, of their Nature, and Relations, is the laſt thing we attain to, when we are Children, as our Minds enlarge, and our Underſtandings open, we are capable to advance, and if our Capacities did conſtantly enlarge and encreaſe, we might perhaps, come diſtinctly to conceive the greateſt *finite* Numbers, with as much Facility as we now do the leaſt, and if our *Comprehenſions*, came at laſt to be *infinite*, we then ſhould conceive, the poſitive Nature of *infinite* Quantities, as eaſily, as we do now *finite* ones; but we know very well that the natural Enlargement of our Minds, and Capacities, ends commonly, at the time of our Maturity; and that all that Study and Application does, is to give us a Facility, in conceiving things, and furniſhes us with variety of Objects; but adds little Vigor, or Force, to the natural *Energy*, of our Minds, ſo that they are very far from arriving to that Strength, ſo as to be able to conceive, the poſitive Nature of *Infinites.* Since then thus it is, ſince it is abſolutely impoſſible for us to ſtretch our Capacities, beyond their preſcrib'd Limits, ſince we can never comprehend the *poſitive* Nature of *Infinites*, we muſt be contented, to improve that Part of *infinites*, which we can attain to, with any probability of Succeſs, and that is their *relative* Nature, or the finite Relations of *infinites* to one another, for it's certain, that *infinites* have to one another, all the Proportions that *finites* have, for an *infinite* Quantity of equal Parts, ſuch as n, has to an infinite Quantity of equal Parts ſuch as Unity, the Proportion that n has to 1.

§ XI. For the more diſtinct Apprehending, the relations of *Infinites* to one another, it is neceſſary we ſhould diſtinguiſh the Parts, an *infinite* Number of which, conſtitutes the *infinite*. Now theſe may be either all unequal, and that in a regular Progreſſion, ſuch as $1 + 2 + 3 + 4 + 5$, &

&c. *in infinitum*, where the Parts that at laſt conſtitute, the *infinite*, are as Natural Numbers; or theſe Parts may be as the *Squares*, *Cubes*, or any other Powers of Natural Numbers, or as the Roots of ſuch Powers; or they may go on in any *Geometrical* Progreſſion aſcending or deſcending from *infinite*, or the Parts may have no regular Progreſſion: all theſe Varieties may happen in the Parts, of which, an *infinite* Number, conſtitutes the *infinite*. Or laſtly, the Parts, of which the *infinite* Number, at laſt conſtitutes or repreſents the *infinite*, may be equal, as $1 + 1 + 1 + 1$, &c. *in infinitum*, or $2 + 2 + 2 + 2$, &c. *in infinitum*; for Diſtinction ſake, let ∞ repreſent or ſignify an infinite Number of Unities or *Infinite* in general, (for ſo I would be underſtood always, when I do not expreſs its *infinitely* ſmall Parts, this I here declare once for all) or $1 + 1 + 1 + 1$, &c. *in infinitum* $= \infty$, alſo let 2∞ or $\infty 2$ or $\infty \times 2$ ſignify an *infinite* Number, whoſe Parts *in infinitum* are 2, and ∞a an *infinite* Number of indetermin'd equal Parts; then $\frac{\infty}{\infty}$

will be equal to i, or the infinitely ſmall part of an infinity of Unities, which is 1. $\frac{\infty 2}{\infty} = 2$ and $\frac{\infty a}{\infty} = a$. alſo $\infty \times \infty = \infty^2$ is an infinite Number of ∞ 1, or $\overline{1 + 1 + 1 + 1, \&c.} \times \overline{+ 1 + 1 + 1 +}$, *&c.* likewiſe $\infty \times \infty \times \infty = \infty^3$ or the Cube of an *infinite* Number of Unites, and ∞^n is the indefinite Power of an *infinite* Number of Unities, and ſo forth.

SCHOLIUM.

From this *Article* and the *Ninth*, the whole *Arithmetick* of *Infinites* with one another, and of *Finites* with *Infinites*, may be deduced; having firſt reduc'd all *Infinites* to thoſe, whoſe infinitely ſmall Parts are equal: thus,

Addition. $2 \infty + \infty 3 = \infty 5$. $\infty a + \infty 2 a = \infty 3 a$. $\infty^2 + 2 \infty^2 = 3 \infty^2$. $\infty^n + p \infty^n = \overline{1 + p} \infty^n$. $\infty a + \infty e = \infty a + \infty e$. $\infty 3 + 10 = \infty 3$. $\infty a + a$

$= \infty a$. $\infty^2 + \infty = \infty^2$ and $\infty^n + \infty^{n-1} = \infty^n$. Let q be leſs than n by any finite Quantity, then $\infty^n + \infty^{n-q}\ \infty^n$.

Subtraction. $\infty 5 - \infty 2 = \infty 3$. $\infty 10a - \infty 3a = \infty 7a$. $\infty 6n - \infty 4n = \infty 2n$ $\infty 5 - \infty 7 = -\infty 2$ or $\infty - 2$, $7\infty^3 - 5\infty^3 = 2\infty^3$. $9\infty^p - 5\infty^p = 4\infty^p$. $5\infty^p - a\infty^p = \overline{5-a}\,\infty^p$. $\infty 3 - 7 = \infty 3$ $\infty a - a = \infty a$. $\infty^p - \infty^{p-1} = \infty^p$ let $q \sqsupset p$ then $\infty^p - \infty^{p-q} = \infty^p$.

Multiplication. $\infty \times 3 = 3\infty = \infty 3$. $\infty \times a = \infty a$. $\infty \times \infty = \infty^2$ and $\infty^2 + \infty^3 = \infty^5$. $\infty^p \times \infty^q = \infty^{p+q}$. $\infty a \times \infty e = ae\infty^2$. $3\infty a \times 4\infty x = 12\infty^2 ax$. $-\infty 2 \times -\infty 3 = +\infty^2 6$. $-\infty a \cdot \times + \infty = -\infty^2 a$.

Diviſion. $\frac{\infty}{2} = \frac{1}{2}\infty$ or $\infty\frac{1}{2}$. $\frac{\infty a}{e} = \infty\frac{a}{e}$. $\frac{\infty 2}{\infty} = 2$. $\frac{\infty 3}{\infty 4} = = \frac{3}{4}$, $\frac{\infty a}{\infty e} = \frac{a}{e}$. $\frac{\infty^2}{\infty} = \infty$. $\frac{\infty^3}{\infty} = \infty^2$. $\frac{\infty^p}{\infty^q} = \infty^{p-q}$. $\frac{+\infty 3}{-\infty} = -3$. and $\frac{-\infty 4}{-\infty 2} = +2$. $\frac{-\infty a}{+\infty e} = -\frac{a}{e}$.

Fractions. $\infty\frac{2}{3} + \infty\frac{4}{5} = \infty\frac{22}{15}$. $\infty\frac{a}{e} + \infty\frac{p}{q} = \infty\frac{aq+ep}{eq}$. $\infty\frac{4}{5} - \infty\frac{2}{3} = \infty\frac{2}{15}$. $\infty\frac{a}{e} - \infty\frac{p}{q} = \infty\frac{aq-ep}{ep}$. $\infty\frac{a}{e} \times \infty\frac{p}{q} = \infty\frac{{}^2ap}{eq}$. $\infty\frac{a}{e}) \infty\frac{p}{q} (= \frac{ep}{qa}$. $\infty\frac{5}{4}) \infty\frac{2}{3} (= \frac{8}{15}$.

Thoſe who are ever ſo little acquainted with the Specious Arithmetick, will eaſily Underſtand the Truth and Reaſon of theſe Operations.

§ XII. Now to illuſtrate this *Arithmetick*, in ſome few Problems; let the firſt be in that of the Sum of an *arithmetical Progreſſion*, equal to y, from having the firſt Term $= a$,

$= a$, the laſt $= v$, and the Common Difference, equal to e, given. Let $\backsim$ ſignify, the Difference of two Quantities when it is uncertain which is greateſt, then $y = \frac{v^2 \backsim a^2 + ve + ae}{2e}$.

If $a = \infty i$ or an *infinite Number* of Unities, and $v = 0$, then $y = \frac{\infty^2 - 0^2 + 0e + \infty e}{2e} =$ (by the Rules of *Addition*) $\frac{\infty^2}{2e}$. And the infinitely ſmall equal Part of ſuch a Sum, or ∞) $\frac{\infty^2}{2e}$ ($= \frac{\infty}{2e}$ or $\infty \frac{1}{2e}$; the ſame happens if $a = 0$ and $v = \infty$. for Exemple, the Sum of a *Series*, of natural Numbers, whoſe firſt Term is 0, and the laſt is ∞, or $1 + 1 + 1 + 1$, &c. *in infinitum*, is equal to $\frac{\infty^2}{2}$. or all the natural Numbers, beginning at 0, and ſtoping at *infinite* (if I may be allow'd to ſpeak ſo) *viz.* $0 + 1 + 2 + 3 + 4 + 5 + 6$, &c. *in infinitum* $= \frac{\infty^2}{2} = \overline{1 + 1 + 1 + 1 + 1, \&c.} \times \overline{\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2}, \&c.} = \infty 1 \times \infty \frac{1}{2} = \frac{\infty^2}{2}$ (by the Rules of

Multiplication,) or the *infinitely* ſmall equal part of ſuch a Sum, is equal to an *infinite* Number of halves.

If inſtead of the common Difference, the Number of Terms $=t$, had been given, then had y, been equal to $\frac{ta+tv}{2}$. where if a be put equal to a finite Quantity, $v=0$, and $t=\infty 1$. then $y=\frac{\infty a+\infty 0}{2}=$ (by the Rules of *Addition*) $\frac{\infty a}{2}$. and the *infinitely* ſmall equal part of ſuch a Sum, or $\infty 1$) $\frac{\infty a}{2}$ ($=\frac{a}{2}$; for Example, if $a=10$, $v=0$ $t=\infty 1$, then $y=\infty 5$. or the Sum of all the poſſible *Arithmetical* mean Proportionals, between 12 and 0, is equal to an *infinite* Number of Five's, or Five is the *infinitely* ſmall equal part of ſuch a Sum of *Arithmetical* mean Proportionals.

Suppoſe $a=\infty n$, $v=\infty m$, $t=\infty p$, $y=\frac{\infty^2 pn+\infty^2 pm}{2}$; thus if *infinites* might be ſuppos'd, in an *Arithmetical* Progreſſion, we ſhould have their Sum; for Exemple, if $n=2$, $m=3$, $p=1$, then $y=\frac{\infty^2 2+\infty^2 3}{2}=$

(by the Rules of *Addition*) $\frac{\infty^2 5}{2}$. and the *infinitely* ſmall equal Part of ſuch a Sum, or $\infty 1$) $\frac{\infty^2 5}{2}$ ($= \infty \frac{5}{2}$.

§. XIII. In a *Geometrical* Progreſſion continued, let the firſt Term be call'd a, the laſt v, the *Ratio* of the Terms r to s, and their Sum y, then $y = \frac{ra \backsim sv}{r \backsim s}$ where if the firſt Term be ∞, the laſt o, y becomes $\frac{r\infty}{r-s}$, for Example, let r to s be as 2 to 1, then a *Geometrical Series* continued, beginning at $\infty 1$, and ending at o, and going on at ſuch a *rate*, *viz.* the *Series* $\infty + \frac{\infty}{2} + \frac{\infty}{4} + \frac{\infty}{8}$, &c. *in infinitum*, *uſque ad o.* $= \frac{\infty 2}{2-1} = \infty 2$. or the *infinitely* ſmall equal part of ſuch a Progreſſion is 2.

And univerſally, if it be required to find the infinitely ſmall equal part of ſuch Progreſſions, let that part be called $\dot{x}$ the $\infty \dot{x} = \frac{\infty r}{r-s}$, and conſequently $\dot{x} = \frac{\infty r}{\infty r - \infty s}$ = (by the Rules of *Diviſions*) $\frac{r}{r-s}$. If r to s be as 2 to 1, then $\dot{x} = \frac{2}{2-1} = 2$. If

r to s be as $\frac{3}{2}$ to 1, then $\dot{x} = 3$. and ſo in other Caſes.

If the firſt Term of the *Series*, and of the *Ratio* of the Terms be the ſame, *viz.* if $r = a$, then $y = \frac{r^2 \backsim s v}{r \backsim s}$. and conſequently if the firſt be finite, and the laſt nothing, $y = \frac{r^2}{r - s}$, as alſo if the firſt be nothing, and the laſt finite $y = \frac{s v}{s - r}$.

If the firſt be finite, and the laſt nothing, and it be required, to find the *infinitely* ſmall equal part of the Sum of ſuch a Progreſſion, then $\infty\ \dot{x} = \frac{r^2}{r - s}$. and conſequently $\dot{x} =$ (by the Rules of *Diviſion*) $\frac{r^2}{\infty\, r - \infty\, s}$. for Exemple, if the firſt Term of the *Series*, and of the *Ratio* of the Terms, be 1, and r to s, as 1 to $\frac{1}{2}$, then $\dot{x} = \frac{1}{\infty\, 1 - \infty\, \frac{1}{2}} = \frac{2}{\infty}$. *i. e.* an *infinite* Number, of ſuch ſmall equal parts is equivalent to 2.

If it be required, to find the *Ratio* of the Terms of a *Geometrical* Progreſſion, continually deſcending, whoſe firſt Term being a given Quantity, may have its Sum at laſt, equal to the Sum of another Progreſſion, begining at a different given Quantity, and going on in a different *Ratio*, ſuppoſe the firſt Term of ſuch a Progreſſion $\frac{1}{a}$, the *Ratio* of the Terms, a to 1, then in that Caſe, both their Sums muſt at laſt be equal, *viz.* $\frac{1}{a-1} = \frac{r^2}{r-s}$, and conſequently $a = \frac{r^2+r-s}{r^2}$; for Exemple, if r to s, be ſuppoſed, as 1 to $\frac{1}{2}$ then $a = \frac{1+1-\frac{1}{2}}{1} = \frac{3}{2}$. and therefore the *Geometrical* Progreſſion, continually deſcending, $1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8}$, &c. *in infinitum*, $= \frac{2}{3} + \frac{4}{9} + \frac{8}{27} + \frac{16}{81}$, &c. becauſe both their Sums are at laſt equal to 2. And thus an *Infinite* Number of different *Series's* may be found, begining at different Quantities, and going on in different *Ratio's*, whoſe Sums, may be at laſt all equal; for if you put, a Quantity leſs than the Sum, for the firſt Term of the *Series*, and of the *Ratio* of the Terms, and put the ſecond Term of the *Ratio* unknown, and then collecting the Sum of ſuch a Pro-

greſſion,

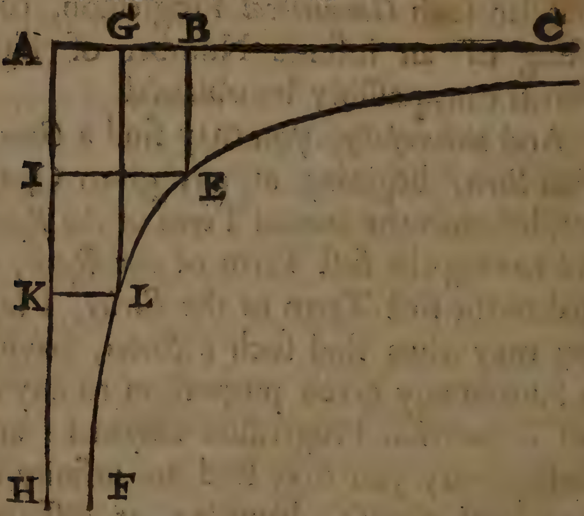
greſſion, make it equal to the Quantity given, to which all their Sums ſhould be equal; you will find the unknown Term of the *Series* ſought; for Exemple, if it were requir'd to find a *Series* begining at $\frac{1}{2}$, and having its *Ratio* $\frac{1}{3}$ to s. which *Series* ſhould be equal, to the Sum of either of the two preceding Progreſſions, which were equal to 2. then $\frac{r^2}{r-s}=$ (in this Caſe) $\overline{\frac{1}{3}-s}\,)\,\frac{1}{9}\,(=\frac{3}{9-27s}=2$. and conſequently $s=\frac{5}{18}$. wherefore, the firſt Term of the *Series*, and of the *Ratio*, being $\frac{1}{3}$, and the ſecond Term of the *Ratio* $\frac{5}{18}$, the *Series* it ſelf is, $\frac{1}{3}+\frac{5}{8}+\frac{25}{108}$, &c. *in infinitum*. $=2$. for $\frac{3}{9-27s}=\frac{3}{9-27\times\frac{5}{18}}=\frac{2}{3})\,3\,(=\frac{6}{3}=2$. ſo that now, to find an *infinite* Number of ſuch *Geometrical* Progreſſions, begining at different Quantities, and going on in different *Ratio*'s, we have no more to do, but to form an improper Fraction (as it's call'd) whoſe *Numerator* being any Number ſuch, that its Denominator, conſiſting of two Terms, or Numbers, join'd by the Sign $-$, its Value may be equal to 2; for then performing the *Diviſion*, according to the *Arithmetick* of *Coſſick* Quantities, we ſhall have the *Series's* ſought; thus, $\frac{4}{7-5} = \frac{2}{9-8} = \frac{6}{7-4} = \frac{8}{9-5} = \frac{10}{15-6}$, &c. $= 2$. The Reaſon why all theſe *Series's* conſiſting of Terms ſo different are at laſt all equal to one another, ſhall be afterwards ſhewn.

§ XIV. Suppoſe the laſt Term of a continued *Geometrical* Progreſſion *infinite*, the firſt finite, then x or the *infinitely* ſmall equal part of the Sum of ſuch a Progreſſion, ſhall be (by the Method uſed in the preceding Article) $\frac{s}{s-r}$. for Exemple, Let the firſt Term be i, the laſt ∞, the *Ratio* of the Terms 1 to 3. the *infinitely* equal ſmall part, of the Sum of the Progreſſion ſhall be $\frac{3}{2}$: Or this Progreſſion reduc'd to its equivalent, in equal parts ſhall be $\frac{3}{2} + \frac{3}{2} + \frac{3}{2} + \frac{3}{2}$, &c. *in infinitum*. Again, let the firſt Term be i, the the laſt ∞, the *Ratio* of the Terms 1, to $\frac{3}{2}$, the *infinitely* ſmall equal part, of the Sum of ſuch a Progreſſion, ſhall be 3. or the Progreſſion it ſelf, ſhall be equal to an *infinite* Number of three's $= 3 + 3 + 3 + 3$, &c. *in infinitum.* And thus we may reduce any *Geometrical* Progreſſion aſcending, begining at a finite Quantity, and ending at ∞, to an *infinite* Number of equal parts.

If it be deſir'd to find a *Geometrical* Progreſſion, which begining at Unity, and having the firſt Term of its *Ratio* Unity alſo, may have its Sum equal to an *infinite* Number of any given equal parts, ſuch as a, $\frac{s}{s - i} = a$, and $s = \frac{a}{a - 1}$, if $a = 4$ then $s = \frac{4}{3}$, if $a = 5$ then $s = \frac{5}{4}$. By ſuch means, you may have an *infinite Multiple* or *Submultiple*, to any other *infinite*, going on in any aſſignable Progreſſion, begining at Unity, and having the firſt Term of its *Ratio* Unity, and the laſt Term of the *Series* infinite; thus if to the Progreſſion, begining at 1, and ending at ∞, and going on in the *Ratio* of 1 to 2. *viz.* $1 + 2 + 4 + 8 + 16$, &c. *in infinitum* $= \infty\, 2$. you would have a Progreſſion, whoſe Sum ſhould be triple of this, you will find it $1 + \frac{6}{5} + \frac{36}{25} + \frac{216}{125}$, &c. *in infinitum* $= \infty\, 6$. If you would have a *Series*, whoſe Sum ſhould be equal to an infinite Number of Unities, then is $s = \frac{1}{1-1} = \frac{1}{0} = \infty$. ſo that no ſuch *Geometrical* Progreſſion, conſiſting of an infinite Number of finite Terms can, poſſibly be obtain'd.

And *univerſally*, you may find a *Geometrical Series* begining at any given Quantity, leſs than the ſecond Term of the *Ratio*, and having the firſt Term of the *Ratio*, equal to the firſt Term of the *Series*, I ſay, you may thus find ſuch a *Series*, having its Sum in any given proportion to any other *Geometrical* Progreſſion aſſigned ; and conſequently you may find an infinity of *Geometrical Series's*, begining at different finite Quantities, and having different *Ratio's* all equal to one another. Let $r \sqsupset s$ and $\frac{s}{s-r} = a$ then $s = \frac{ra}{a-1}$ and $r = \frac{sa-s}{a}$.

ſo that ſuppoſing one of the Terms of the *Ratio* aſſum'd at pleaſure, you may find the other; and making the firſt Term of the *Series* begin with the firſt Term of the *Ratio*, you may have infinitely different *Geometrical* Progreſſions, all whoſe Sums may be equal.



§ XV. Let there be a *Curve DEF*, whoſe *Abſciſſes AK*, are computed from the fixt point *A*. in the *Axe AIH*, let

AI = *IE* be 1. *AK* = x, *KL* = y, and the *Equation* of the *Curve* be $y = \frac{1}{x^n}$. then by the *common Methods* of *Quadratures*, the indefinite *Area ABCDELK* will be $\frac{x^{1-n}}{1-n}$, and the indefinite *Area* *AGLFHKI* will be $\frac{nx^{1-n}}{1-n}$. Now if $n = 1$ then the *Equation* of the *Curve* will be $y = \frac{1}{x}$, and the *Area ABCDELK* will be equal to $\frac{x^{1-1}}{1-1} = \frac{1}{1-1} = 1 + 1 + 1 + 1 + 1 +$, &c. continued *in infinitum*, ſo that Unity, is the *infinitely* ſmall equal part, of the *Area* of the *Apollonian Hyperbola*.

If the Indefinite *Area AGLFGKI* be requir'd, then (becauſe $x = y^{-\frac{1}{n}}$ in that Caſe) it becomes $\frac{ny^{\frac{n-1}{n}}}{1-n}$. and where $y = 1$, as alſo $n = 1$ that *Area* becomes $\frac{2-1}{1-1} = \frac{1}{1-1} = 1 + 1 + 1 + 1 + 1$, &c. *in infinitum*, ſo that it is evident, that the ſpace adjacent, to both the *Aſymptotes* of the *Appollonian Hyperbola*, is infinite; and the whole Space on both *Aſymptotes* = ∞ 2:

If $n = 2$. the *Area* $ABCDLK$, becomes $\frac{x^{1-2}}{1-2}$, or (computing only to *I*, where $AI = x = IE = 1$) the *Area* $ABCDEI$ $= \frac{1^{1-2}}{1-1} = 1 - 2)\,1\,(= 1 + 2 + 4 + 8 + 16$, &c. Now this is a *Geometrical* Progreſſion, whoſe firſt Term is 1, and if it be continued only till its laſt be ∞ 1, ſince the *Ratio* of the Terms is 1 to 2. its *infinitely* ſmall equal part, by the *preceding Article*, will be $x = \frac{s}{s-r} = \frac{2}{2-1} = 2$. and ſo the interminated Space, contain'd between the *Curve* and its *Aſymptote*, in this *Hyperboloid*, would be equal to an *infinite* Number of two's, or ∞ 2. as alſo this Space would be double of the *Appollonian Hyperbolick* Space. And likewiſe, becauſe when $n = 2$, and $y = 1$, the Space $BEFH$ $= \frac{ny^{\frac{n-i}{n}}}{n-1} = \frac{1}{2-1} = 2 - 1)\,2\,(= 1$

$+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}$, &c. whoſe firſt Term is 1, and laſt 0, and the *Ratio* of the Terms 1 to $\frac{1}{2}$, or 2 to 1, therefore by the *preceding Article*, the Sum of the Terms is $\frac{2}{2-1}=2$. So that the whole *Aſymptotical* Space of the *Hyperbola* whoſe *Equation* is $y x^2 = 1$, would be $\infty 2 + 2 = \infty 2$, upon ſuppoſition that the greateſt Term of its unequal Progreſſion were only Infinite or $\infty 1$. If $n = 3$ and $x = 1$. then the *Area* $AIEDC = \frac{1}{1-3} = 1 + 3 + 9 + 27$, &c. = (by the *preceding Section*) $\frac{3}{2}+\frac{3}{2}+\frac{3}{2}+\frac{3}{2}$, &c. when the laſt Term is only $\infty 1$. and if $n = 3$, and $y = 1$, the *Area* $ABEFH = \frac{3}{3-1} = 1 + \frac{1}{3} + \frac{1}{9} + \frac{1}{27}$, &c. and the whole *Aſymptotick* Space of this *Hyperboloid*, is equal to $\infty \frac{3}{2} = \frac{3}{2}+\frac{3}{2}+\frac{3}{2}+\frac{3}{2}$, &c. upon that Suppoſition. And Univerſally, if $x = 1$, then the Space $AIEDC = \frac{1}{1-n} = 1 + n + n^2 + n^3 + n^4$, &c. whoſe infinitely ſmall equal part (ſuppoſing the laſt Term of the *Series* only $\infty 1$.) by the *pre-*

ceding Section, is $\frac{n}{n-1}$, and conſequently this *Series* is equal to $\infty \frac{n}{n-n} = \frac{n}{n-1} + \frac{n}{n-1} + \frac{n}{n-1} + \frac{n}{n-1}$, *&c.* and if $y = 1$, then the Space *ABEFH* $= 1 + \frac{1}{n} + \frac{1}{n^2} + \frac{1}{n^3} + \frac{1}{n^4}$, *&c.* the Sum of which is $\frac{n}{n-1}$. ſo that the whole Space, comprehended between theſe *Curves, in infinitum*, and both *Aſymptotes*, of ſuch exterior *Hyperboloids*, (putting $AB = AI = 1$.) is equal to $1 + \frac{n}{n-1} + n + n^2 + n^3 + n^4$, *&c.* $= \infty \frac{n}{n-1}$. upon ſuch a Suppoſition. Hence it appears in ſome part, what thoſe *Geometers* meant by the *Area's* of theſe *Hyperboloids*, which in their Language were call'd *pluſquam infinitæ*, or more than *infinite*, which might be, that ſome of theſe *Hyperbolick* Spaces, had the equal parts of which they conſiſted, in certain *Ratio's* to one another, when the laſt Term of the *Series* was only ∞; thus the *Area* of the *Appollonian Hyperbola*, conſiſts of an *infinite* Number of Unities, the *Area* of the *Hyperbola*, whoſe *Equation*, is $yx^2 = 1$, of an *infinite* Number of two's; the *Area* of the *Hyperbola*, whoſe *Equation* is $yx^3 = 1$ of an *infinite* Number of $\frac{3}{2}$'s; but here the *infinite* Number of equal parts, of which the *Area* of this *Curve* conſiſts, muſt be much greater than the *infinite* Number of equal parts, of which the former two conſiſts, to exhauſt the whole *Area* of the *Aſymptotick* Space, for the whole Space in this, is greater than the whole in either of the other two, as every Body knows; ſo that though the Parts be leſs, the Sum muſt be more, as ſhall be afterwards ſhewn.

If it be required, to find the *Equation* of a *Hyperboloid*, that ſhall with the *Aſymptote* *ABCDEI*. Suppoſing the laſt Term only ∞ 1, let the Expreſſion of the given *Hyperbola*, which contains with the *Aſymptote*, *ABC*, the given *infinite* Space, be $y = x^{-n}$. Let the *Multiple* or *Submultiple* required, be a, then it's plain that $\frac{n}{n-1}$ muſt be equal to a, and conſequently $n = \frac{a}{a-1}$; for Exemple, let the given *Equation* be $y = \frac{1}{x}$, and conſequently the given *infinite* Space $= 1 + 1 + 1 + 1 + 1$, *&c.* and let it be required to find another *infinite* Space, whoſe equal parts may be triple of this, then $n = \frac{a}{a-1} = \frac{3}{3-1} = \frac{3}{2}$ and ſo the *Equation* will be $y = x^{\frac{-3}{2}}$, and a part of the *infinite* Space it ſelf $= 3 + 3 + 3 + 3 + 3$, &c. *in infinitum.*

Now, becauſe, ſome of theſe Inferences, may appear a little odd, and perhaps falſe, to ſome People, to ſave the trouble of *Animadverſions* (if it be poſſible) I ſhall here obviate ſome Objections, that might be made againſt them; and 1. If it be objected, that of an *Arithmetical*, or *Geometrical* Progreſſion, aſcending, or deſcending, *in infinitum* to ∞ or *o*. it is impoſſible, the Sums ſhould be equal, to an *infinite* Number of equal parts, for ſince all the parts are ſuppos'd to be unequal, the Sums cannot be equal; the ſame Objection takes place in *Geometrical* Progreſſions, aſcending or deſcending to ∞ or *o*; whoſe Terms have different *Ratio's*, and which begin at different given Quantities, and yet their Sums are ſuppos'd equal, or in a given *Ratio* to one another; for Exemple, how the *Series* $1 + 2 + 3 + 4 + 5 + 6$, &c. continued to ∞. ſhould be equal to $+ \frac{\infty}{2} + \frac{\infty}{2} + \frac{\infty}{2} + \frac{\infty}{2}$, &c. continued till the Number of the Terms become equal to ∞ 1. How $1 + 2 + 4 + 8 + 16$, &c. continued to ∞. ſhould be equal to $2 + 2 + 2 + 2 +$, &c. continued till the Number of Terms be equal to ∞ 1. How the Sum of $1 + 2 + 4 + 8$, &c. continued to ∞ 1, ſhould be but the third part of the Sum of $1 + \frac{5}{6} + \frac{6^2}{5^2} + \frac{6^3}{5^3}$, &c. continued to ∞. Since all the parts of the firſt two *Equations* are unequal, and the parts of the third, have no ſuch Proportion, as their Sums are ſuppos'd to have. In Anſwer to theſe, let us Conſider, 1. that there an *infinite* Number of *Series's*, whoſe Sums may actually *infinite*, below an *infinite* Number of Unities, as well as above it; for Exemple, as above an *infinite* Number of Unities, there is an *infinite* Number of two's, of three's, of fours, &c. *in infinitum*; ſo below an *infinite* Number of Unities, there are an *infinite* Number of halv's, of one thirds of one fourths, &c. *in infinitum*, all whoſe Sums are actually *Infinite*, *viz.* as above $\infty\ 1 = 1 + 1 + 1 + 1$, &c. there is $\infty\ 2 = 2 + 2 + 2 + 2$, &c. and $\infty\ 3 = 3 + 3 + 3 + 3$, &c. and ſo forth; ſo below $\infty\ 1$ there is $\infty\ \frac{1}{2} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2}$, &c. and $\infty\ \frac{1}{3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$, &c. and ſo on, all which are real *infinite* Quantities; for an *infinite* Number, of finite Quantities whatſoever, makes an *infinite* Quantity; and therefore the Sum of an *infinite Series*, may be equal to the Sum of another *infinite Series*; tho' their parts be all unequal, and both have an *infinite* Number of parts, becauſe, tho' the Number of parts in both, be *infinite*, yet they may be different *infinits*, the one a Greater, the other a Leſs; thus for Exemple, $1 + 2 + 4 + 8 + 16$, &c. continued to $\infty\ 1$. may be equal to $2 + 2 + 2 + 2$ &c. continued till all the Number of parts, be equal to $\infty\ 1$. becauſe the firſt *Series*

ries encreaſes faſt, and always doubles the preceding Term, and ſo quickly arrives at ∞ 1. whereas the ſecond goes on at the ſame equable Rate, ſo that there is not ſo great a Number of Terms in the firſt *Series*, as in the ſecond; for let the Number of Terms of a *Geometrical* Progreſſion continued, be, t the *Ratio* of the Terms r, the greateſt v, and the leaſt a, then $rv = ar^t$. and $t = \frac{Log.\, rv}{Log.\, ar}$. in this Caſe, where $r = 2$, $a = 1$, $v = \infty$. t, becomes $\frac{L\infty}{L\,2}$. Now it is certain that the Logarithm of ∞, is only, not *infinitely* leſs, than ∞; therefore the Number of Terms, in the firſt *Series*, is conſiderably leſs, than the Number of Terms in the ſecond *Series.* But 3. more particularly, in the *Arithmetical* Progreſſion of natural Numbers, begining at i and ending at ∞, becauſe the Sum of all ſuch is equal to the half of the Rectangle of the greateſt, into the Sum of the Terms; therefore $1 + 2 + 3 + 4 + 5$ &c. continued to $\infty = \frac{\infty^2}{2}$. becauſe both the laſt, and the Sum of the Terms is ∞; then as for the *Geometrical* Progreſſion Aſcending *in infinitum, viz.* $1 + 2 + 4 + 8$ &c. *uſque ad* ∞. it is evident, every Term here is equal to the Sum of all the former $+ 1$. and ſince the laſt Term is ſuppos'd *infinite*, or $\infty 1$, therefore $\infty 1 - 1$, is equal to the Sum of all the foregoing Terms, and therefore the laſt, with all the preceding, is equal to $\infty 1 + \infty 1 - i =$ (by the Rules of *Addition*) to $\infty 2$. in like manner in the *Geometrical* Progreſſion continually aſcending, from 1 to ∞. in the *Ratio* of 1 to 3, *viz.* $1 + 3 + 9 + 27$ &c. *uſque ad* ∞. becauſe every Term $- 1$, is double of all the preceding Terms, and becauſe the laſt Term is $\infty 1$, therefore the Sum of all the Terms except the laſt, is $\frac{\infty}{2} - 1$; and conſequently the Sum of the laſt, and of all the preceding Terms, is $\infty 1 + \frac{\infty 1}{2} - 1 =$ (by the Rules of *Addition*) $\infty \frac{3}{2}$. where it is obſervable, that the *Series* $1 + 2 + 4 + 8$ &c. continued to $\infty 1$. is greater, than $1 + 3$

+9

$+ 9 + 27$, &c. continued to $\infty\, 1$, becauſe there are more Terms in the firſt, than in the ſecond; the ſecond diverging faſter, and at a greater Rate than the firſt, arrives at $\infty\, 1$ ſooner, *i. e.* after a fewer Number of Terms than the firſt. So likewiſe, if the *Series* be $1 + 4 + 16 + 64$, &c. continued to $\infty\, 1$, then every Term $- 1$ is triple of all the Sum of the preceding Terms, and conſequently the Sum of all $= \infty\, \frac{4}{3}$; and univerſally, the *Geometrical* Progreſſion begining at 1, and going on continually to $\infty\, 1$. in the *Ratio*, of 1 to n, viz. $1 + n + n^2 + n^3 + n^4$, &c. Every Term $- 1$ is $\overline{n-1}$ times, the Sum of all the preceding, and becauſe the laſt is $\infty\, 1$, therefore the Sum of all the preceding, is $\frac{\infty\, 1}{n-1} - 1$. and conſequently the Sum of the laſt, and of all the preceding, is $\infty\, 1 + \frac{\infty\, 1}{n-1} - 1 =$ (by the Rules of *Addition*) to $\infty\, \frac{n}{n-1}$. Laſtly, as for the two *Series's* $1 + 2 + 4 + 8$, &c. continued to $\infty\, 1$

and $1 + \frac{5}{6} + \frac{6^2}{5^2} + \frac{6^3}{5^3}$, &c. it is evident that the Number of Terms in the firſt, is much fewer than in the ſecond, for the Number of Terms as has been ſhewn, is $t = \frac{Log.\ vr}{Log.\ ar}$. which in the firſt becomes $\frac{Log.\ \infty}{Log.\ 2.}$. and in the ſecond $\frac{Log.\ \infty}{Log.\ \frac{6}{5}}$. both which have the ſame Numerators, but the Denominator of the firſt is much greater, than that of the ſecond, and conſequently the Number of Terms in the firſt, is much leſs, than the Number of Terms in the ſecond.

It may be objected, that the *Hyperbolick Area* *A F D C B* (ſee the following Figure) is found equal to $1 + 1 + 1 +$, &c. continued till the Number of Terms be infinite, and (taking $AB = 1 =$ to the Inſcribed ſquare) yet the *Area* of the *infinitely* long *Parallelogram* *A F G B* is no more than $1 + 1 + 1 + 1$, &c. continued *in infinitum*, from whence it would ſeem to follow that the Space *A F D C B*, were equal to the *Parallelogram* *A F G B*, which is abſurd.

To this it is anſwered, that tho' each of theſe, be equal to an *infinite* Number of Unities, yet the Spaces are not equal, becauſe that *infinite* Number, is not the ſame in both, and the reaſon why that *infinite* Number, is not the ſame in both, is becauſe (tho' both FC and FG meet at an *infinite* Diſtance, with AB, yet) FC meets ſooner with AB, than FG with AB, *i. e.* ſuppoſing the Diſtance between A and B (the Concurſe of FD and AB) $= \infty a$, and the Diſtance between A and B (the Concurſe of FG with AB, if I may be allow'd to ſpeak ſo) $= \infty b$, then b will be greater than a. And conſequently we ſhall have $AFDCB = 1 + 1 + 1 + 1 + 1$, &c. $= \infty c \times 1$, and $AFGB = 1 + 1 + 1 + 1 + 1$, &c. $= \infty d \times 1$, where d, is greater than c and therefore $AFGB \sqsubset AFDCB$. Not only ſo, but a *Parallelogram*, whoſe Breadth is 1, and whoſe Length is ∞a, (or the Diſtance between A and the Concurſe of FC with AB) is greater, than the *Hyperbolick Area*. To make this yet more plain, let $AK = GL$

(ſee the preceding Figures) be call'd x, KL y, and $AI = IE$ be 1. Let n be an *integer* Number, then $y = x^{-n}$, expreſſes the Nature of an *infinity* of *Hyperboloids*, from this you have $x = \frac{1}{\sqrt[n]{y}}$ *i.e.* $GL. = \frac{1}{\sqrt[n]{y}}$, which ſhews, that the greater you ſuppoſe n to be, the longer will the *ordinate* GL be, in reſpect of the ſame *Abſciſs* AG; for Exemple, of two *Curves* $yx^2 = 1$, $yx^3 = 1$ (of which the former gives $GL = \frac{1}{\sqrt[2]{y}}$, the other $GL = \frac{1}{\sqrt[3]{y}}$) that which has $n = 3$ (*viz.* $yx^3 = 1$) ſhall have a longer *Ordinate*, GL, than the former, which has $n = 2$. and conſequently the point L in the firſt ($yx^2 = 1$) ſhall approach nearer to AC, than the point L in the ſecond ($yx^3 = 1$) when you take AG the ſame in both; and therefore the greater you ſuppoſe n, the longer will it be, before the *Curve* LED meet with the *Aſymptote* AC, but they all meet with AC, at an *infinite* Diſtance from A, *viz.* when GL is $= 0$, and therefore theſe *infinite* Diſtances *AC* muſt be different according to the different Values of of n; and conſequently of any two of theſe *Hyperboloids* $y x^2 = 1$, whoſe Concurſe with the *Aſymptote* *AC*, we ſhall denote by ∞a; and $y x^3 = 1$, whoſe Concurſe with *AC*, we ſhall denote by ∞b, I ſay that a is leſs than b.

Suppoſe $n = \infty$, then $GL = \frac{1}{\sqrt[\infty]{y}} = \frac{1}{y^{\frac{1}{\infty}}} = \frac{1}{y^0} = \frac{1}{1} = 1$, in which Caſe the *Ordinate* *GL*, is conſtantly 1. which is the property of the *Parallelogram* *ACXGL*, which ſhews that all the *Hyperboloids* $y x^n = 1$, meet with the *Aſymptote* *AC*, before *KL*, infinitely produc'd, meet with it; as alſo becauſe $y x^{\infty} = 1$, is the *Equation* for the infinite *Parallelogram*, it may be reckon'd among the *Hyperboloids*. Theſe things duly conſidered will remove all the Difficulties ariſeing in the different Expreſſions, of the *Hyperbolick* Spaces, in reſpect of the infinite *Parallelogram*, for the Unity is the ſame in both, only the Number of the

Terms in all of them is different, and in all of them, leſs than the Number of Terms in the *infinite Parallelogram.*

It may likewiſe ſeem odd, why for Exemple, the equal parts of which the *Area* of the *Aſymptotical* Space, of the *Hyperboloid*, whoſe *Equation* is $yx^2 = 1$ conſiſts, ſhould be $2 + 2 + 2 + 2 + 2$, &c. *in infinitum*, and yet, the equal parts of which the *Area's* of the *Aſymptotical* Space, of the others *in infinitum* conſiſt, ſhould be leſs, for Exemple, $\frac{n}{n-1} \sqsupset 2$. (where n is an *integer* Number.) And yet its certain, the *Area's* of theſe laſt are greater than the *Area* of the firſt, whoſe *Equation* is $yx^2 = 1$. But the Difficulty will vaniſh, if we apply what has been already ſaid to this Caſe, for it's certain that the Number of Terms of theſe laſt, muſt be greater than the Number of Terms in the firſt, (if we ſuppoſe that theſe equal parts exhauſt the whole *Areas's*) for if the Number of Terms in the firſt, whoſe equal parts are $2 + 2 + 2 + 2 + 2$, *&c.* be equal to ∞a, the

Number of Terms in the others, whoſe equal parts are $\frac{n}{n-1} + \frac{n}{n-1} + \frac{n}{n-1} + \frac{n}{n-1}$, *&c.* where $2 \sqsubset \frac{n}{n-1}$, be equal to ∞e, then e muſt be greater than a. But the Truth of the Matter is, that the Invention, or the Ground of the Diſcovery, of theſe equal Parts; in the *Aſymptotical Space* of theſe *Hyperboloids*, is that they all ſtop, in their unequal Progreſſions, at $\infty 1$. for Exemple, in the *Series* $1 + n + n^2 + n^3 + n^4 + n^5$, *&c. in infinitum*, which expreſſes the *Aſymptotical* Spaces *AIEDC*, the Invention of its *infinitely* ſmall part $\frac{n}{n-1}$, depends upon the Suppoſition, that all theſe *Series's* ſtop at $\infty 1$, and go no further, whereas to give the true *Hyperbolick* Spaces, they muſt be all ſuppos'd, to go on, an equal Number of *infinite* Times. Now ſome of 'em, diverging faſter, than others, (thoſe, *viz.* where n is the greateſt Number) arrive at $\infty 1$ ſooner, and ſo by theſe means an *infinite* Number of the equal parts, obtain'd upon this Suppoſition, cannot be equal to the *infinite* Number of unequal parts which conſtitute the *Area*; thus

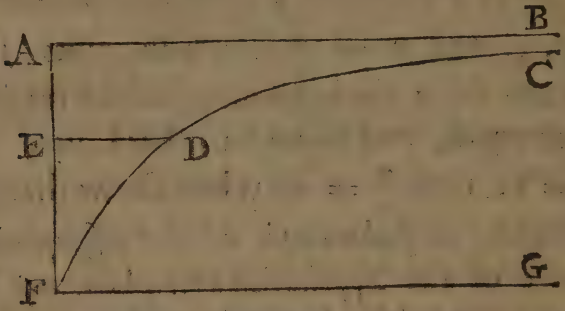
$1 + 2 + 4 + 8 + 16$, &c. is equal to the *Area* of the *Curve* whoſe *Equation* is $yx^2 = 1$; and $1 + 3 + 9 + 27 + 29$, &c. equal to the *Area* of the *Curve* whoſe *Equation* is $yx^3 = 1$, and as the *Area* of this laſt, is greater than that of the firſt, ſo are the parts reſpectively; but the firſt reduc'd to equal parts, is $2 + 2 + 2 + 2 + 2$, &c. whereas the ſecond is but $\frac{3}{2} + \frac{3}{2} + \frac{3}{2} + \frac{2}{3}$, &c. which parts are leſs than the former; whereas the ſecond *Area* is greater than the firſt; but the reaſon of this diverſity is, becauſe the ſecond *Area* arrives ſooner at $\infty 1$, than the firſt. And the Denomination of the infinitely ſmall equal part, is taken from its arriving at $\infty 1$, without conſideration of the Quickneſs or Slowneſs thereof, ſo that the unequal parts, which diverge faſteſt, have the leaſt *infinitely* ſmall equal parts, tho' in the mean time, they make the greateſt *Area*; when an equal infinite Number of parts are taken, as they ſhould do. If it were poſſible to find the infinitely ſmall equal parts, of the *Hyperboloidical* Spaces, from the Number of

Terms being given $= \infty 1$ or ∞a, then we ſhould infallibly, have the Relation of theſe Spaces to one another; but to me, at leaſt, it ſeems impoſſible, without knowing what the *Logarithm* of an *infinite* Quantity is, in it's poſitive Nature, ever to arrive at a compleat Comprehenſion, even of the *Relative* Natures of theſe *infinite* Spaces, for theſe equal parts, which I have uſed to repreſent in ſome manner their Relations, do not at all extend to the whole Spaces, but to an *Abſciſs*, which is equal in them all. I know no way, the Relations, of theſe *infinite Aſymptotical* Spaces to one another, can be expreſs'd, but one of theſe two, ſuppoſe the *Exponent* of the *Abſciſs* of the one be p, of the other n, then theſe Spaces ſhall be one another, as $\frac{1}{1-p}$ to $\frac{1}{1-n}$, or as $\frac{p^{\infty+1}}{p-1}$, to $\frac{n^{\infty+1}}{n-1}$; both which Expreſſions, are equally unintelligible; but if we deſire to find the *Exponent*, ſuppoſe p, of the *Curve*, whoſe Space ſhall be in a given *Ratio*, ſuppoſe 1 to m, to the other; then $\frac{1}{1-p} = \frac{m}{1-n}$, and and $p = \frac{m+n-1}{m}$. where if $n = 2, m = 3$; then $p = \frac{4}{3}$. if $n = 2$, $m = 2$, $p = \frac{3}{2}$. ſo that the *Equation* of the *Curve*, which ſhall have its *infinite Aſymptotical* Space, double of that whoſe Expreſſion is $yx^2 = 1$, is $yx^{\frac{3}{2}} = 1$: and the Spaces are (puting $x = 1$) $1 + 2 + 4 + 8 + 16$, &c. $1 + \frac{3}{2} + \frac{9}{4} + \frac{27}{8} + \frac{81}{16}$, &c. and the Reaſon why this laſt Space is double of the firſt, is becauſe the Terms of the latter in thoſe remoter, become greater than the ſame Terms of the firſt numbred from the begining, which happens, after the firſt Term in both, equally diſtant from the begining of the *Series*, becomes equal; and this in theſe Caſes, is always an aſſignable Term, for Exemple, the ſecond Term in the firſt is 2, in the ſecond, is $\frac{3}{2}$. and the reſt of the Terms aſcend reſpectively in the Powers of theſe Numbers, and if the Exponent of the

Power of 2 and $\frac{3}{2}$ be required that ſhall make them both the ſame Number then $2^n = \frac{3^n}{2^n}$ and $2^{2n} = 3^n$ and $2\,n\,Log.\,2 = n\,Log.\,3$. and $n = \frac{Log.\,3}{Log.\,2}$. which gives the Term, from the beginning, which renders both equal, and ſo on in other Caſes, If $n = 1$, then $\frac{m}{n} = 1$. which ſhews that no *Multiple*, or *Submultiple* of the *Aſymptotical* Space of the *Appollonian Hyperbola*, can be found but it ſelf, ſo that it muſt be the firſt and loweſt *infinite* Space; that as Unity, is its own Square, Cube, *&c.* or its own *Root*, ſo the *Aſymptotical Space* of the *Appollonian Hyperbola* is its own *Multiple* and *Submultiple*.

§ XVI. From the fixt Point *A*, draw the *Indefinite* right Line *AB*, at *A* erect a perpendicular $AF = 1$, and from *F*, draw an indefinite Parallel to *AB*. It is evident, that if *AB*, *FG*, were produc'd *in infinitum*, the *Parallelogram AFGB* would contain an *infinite* Space $= \infty \times 1 = AB \times AF$.

It is requir'd to find the Nature of a *Curve*, *FDC*, which ſhall with the *Aſymptote AB*,



contain an interminated Space, *ABCDF* equal to *AB*, multiply'd into any finite Number whatſoever, or equal to a finite Space, repreſented by any finite given Number, let this finite Number be call'd a, the ordinate *ED* be call'd y, the *Abſciſs* *EA*, x. and let lx ſignify the *Logarithm* of x, then the *Equation* of the *Curve* ſhall be $y = x^{\frac{1}{\sqrt{a}}-1}\, lx$. for Exemple, let a be equal to 4. then the *Equation* becomes $y = x^{-\frac{1}{2}}\, lx$. and the *Area* is $2\, x^{\frac{1}{2}}\, lx - 4\, x^{\frac{1}{2}}$ where putting $x = 1$, and conſequenly $lx = 0$.

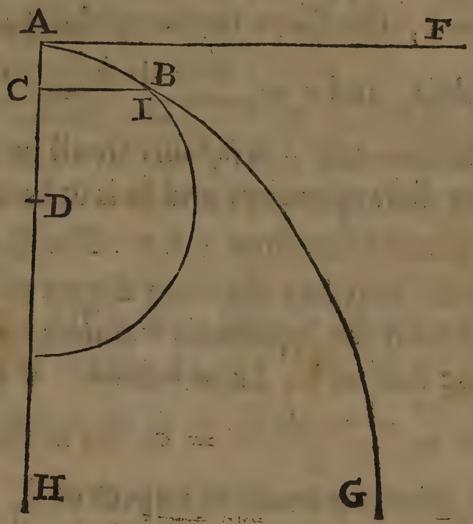
$= 0$. we have this *Area* $= -4$. which, (becauſe the *Curve* continued, cuts the *Axe* aſſum'd,) becomes $+4$. for the whole *Area* $AFC\mathfrak{B}$. If $a = 9$. then that Space is alſo 9. $= 9\,AF \times AF = 9\,\overline{AF}|^2$.

The ſame may be obtained, from the *Hyberbolical Curves* (ſee the Figure of the *preceding Article*,) let $A\mathfrak{B} = AI$ be 1, and let $\mathfrak{B}E$ be produc'd *in infinitum*, the general *Equation* for the whole *Aſymptotical Space* $A\mathfrak{B}EFGI$ is $x = y^{-\frac{n}{1}}$ and calling y, 1, the *Area* is $\frac{1}{1-\frac{1}{n}}$, let the given Number to which we would have the interminated Space equal be a, and let $m = a + 1$, the *Exponent* of the *Curve* ſought ſhall be $n = \frac{1}{1-\frac{1}{m}}$. and ſubſtracting Unity ($=$ to the Square $A\mathfrak{B}EI$) from the *Area* thus found, we ſhall have the remaining *Area* $IEFG = a$. for Exemple, let $a = 3$, then $m = 4$, and $n = \frac{1}{1-\frac{1}{4}}$, and conſequently $x = y^{-\frac{3}{4}}$, and the intermediate *Area* $A\mathfrak{B}EFGI = \frac{y^{1-\frac{3}{4}}}{1-\frac{3}{4}} = \frac{1}{1-\frac{3}{4}}$ (calling $y = 1$)

$= 4$

$= 4 = 1 + \frac{3}{4} + \frac{9}{16} + \frac{27}{64}$, &c. *in infinitum*, from which ſubſtracting Unity ($= ABEI$) we have the the interminated Space *IEEG* $= + \frac{3}{4} + \frac{9}{16} + \frac{27}{64}$, *&c.* $= 3$. Hence it is evident that two interminated *Area's* of two different *Curves* may be found, the Sum or Difference of whoſe *Areas's*, may be equal to any *finite* Space, for in the former Solution, $9 + 4 = 13$ and $9 - 4 = 5$.

§ XVII. Having illuſtrated the *Arithmetical* Operations of *relative Infinites*, in ſome few *Problems*, that involve Quantities *infinitely* Great, let us now apply the ſame, to *infinitely* ſmall Quantities, from the fixt Point *A*, to the *Axe AH*, let the *Curve ABG* be deſcribed, whoſe *Ordinate CB* being y its *Abſciſs AC* x, its *Equation* is $y = x^{\frac{m}{2}}$ with the *Radius AD* $= r$, let a *Semicircle AIE* be deſcribed, and let it be requir'd to find the *Radius r*, of the Circle which may have at the *Vertex A* the ſame Degree of *Curvature*, with the *Curve* deſcrib'd *ABG*, whoſe *Tangent* to the *Vertex* is *AF*.



Let *C*, be the next Point in the *Axe* to *A*, and ſo *AC* ſhall become *infinitly* ſmall, or equal to the *Fluxion* of the *Abſciſs* $= \dot{x}$, and then the *Equation* of the *Circle*, will be $y^2 = 2r\dot{x} - \dot{x}^2$, and the *Equation* of the *Curve* $y = \dot{x}^{\frac{m}{2}}$. But if *A* and *C* coincide, then *I* and *B* muſt likewiſe coincide, becauſe, the *Circle* is ſuppos'd to have theſe

Points at the *Vertex* common with the other *Curve*, and conſequently $2 r \dot{x} - \dot{x}^2 = \dot{x}^m$, and $r = \frac{\dot{x}^m - \dot{x}^2}{2\dot{x}} = \frac{\dot{x}^{m-1} + \dot{x}}{2}$. So then if $m = 1$, the *Curve* becomes the *Appollonian Parabola*, and $r = \frac{\dot{x}^{1-1} + \dot{x}}{2} = \frac{1 + \dot{x}}{2}$, but in this caſe $\dot{x}$ is *infinitly* ſmall in reſpect of any *finite* quantity, and ſo is to be thrown away and r becomes $\frac{1}{2}$ *i.e.* The *Radius* of a *Circle*, that has the ſame degree of *Curvature*, with the *Appollonian Parabola*, is equal to one half of its *Latus rectum*. If $m \sqsubset 1$, then $r = \frac{\dot{x}^{m-1} + \dot{x}}{2} = 0$, for in that Caſe $\dot{x}^{m-1}$ is *infinitly* ſmall in reſpect of $\dot{x}$, and $\dot{x}$ is to be ſuppos'd 0, or *infinitly* ſmall, when x is a flowing Quantity. Wherefore the *Radius* *AD* is *infinitly* ſmall, or the *Curvature* of ſuch *Curves* *ABG*, is *infinitly* great at the *Vertex*, in reſpect of the *Curvature* of the *Circle*, or between the *Tangent* *AF*, and the *Curve* *AB*, no *Circle* can fall. If $m \sqsupset 1$, then $r = \frac{\dot{x}^{m-1} + \dot{x}}{2} = \infty$. For in that

Caſe the *Exponent* of $\dot{x}$ in the firſt Term of the Value of r, becomes Negative, and $\dot{x}$ in the ſecond Term, being ſuppos'd *infinitly* ſmall, r becomes equal to $\frac{1}{0} = \infty$. And ſo the *Curvature* of ſuch *Curves*, at their *Vertex*, is *infinitly* ſmall (for in all ſuch Caſes, the *Curvature* at the *Vertex* is reciprocally proportional to the *Radius* of the *Circle* which touches the *Curve* at that *Vertex*) in reſpect of the *Curvature* of a *Circle*, and ſo the *Curve* *AB* will fall within the *Circle* *AI*, or the *Circle* will cut the *Curve*.

Exemples. If $m = 2$, then $r = \frac{2\dot{x}}{2} = \dot{x} = 0$. If $m = 3$, then $r = \frac{\dot{x}^2 + \dot{x}}{2} = \frac{\dot{x}}{2} = 0$. If $m = \frac{1}{2}$, then $r = \frac{\dot{x}^{-\frac{1}{2}} + \dot{x}}{2} = \frac{1}{\sqrt{\dot{x}}} = \frac{1}{0} = \infty$. If $m = \frac{1}{3}$ then $r = \frac{\dot{x}^{-\frac{2}{3}} + \dot{x}}{2} = \frac{1}{2\sqrt[3]{\dot{x}^2}} = \frac{1}{0} = \infty$. Let m be any Number, *integer* or *fraction*, let there be two *Curves*, whoſe *Equations* are $y = x^{\frac{m}{2}}$, and $y = \frac{x^{m-1}}{2}$, the *Radius*'s of their *Curvatures* at the *Vertical* Point *A*, will be, $\frac{\dot{x}^{m-1}+\dot{x}}{2}$, and $\frac{\dot{x}^{m-2}+\dot{x}}{2}$, and if *m* be an *integer*, or a *fraction* the *Radius* of the *Curvature* in the firſt *Curve*, is *infinitly* little, in reſpect of the *Radius* of the *Curvature* in the ſecond; for in that Caſe $\frac{\dot{x}^{m-1}+\dot{x}}{2} : \frac{\dot{x}^{m-2}+\dot{x}}{2} :: \dot{x}^{m} : \dot{x}^{m-1}$, But $\dot{x}^{m}$ is nothing, or *infinitly* ſmall, in reſpect of $\dot{x}^{m-1}$, *viz.* as $\dot{x}$ to 1, or 0 to 1. And therefore the *Curvature* of the firſt Kind of *Curves*, is *infinitly* great, in reſpect of that of the ſecond. And thus *infinities's* of *Series's* of the *Exponents* of ſuch *Curves*, may be found, of which the *Curvature*, of the preceding, may be infinitely Greater or Smaller, than *Curvature* of the immediatly following.

§ XVIII. Having thus explain'd, the Relations of *Infinites* to one another, I ſhall only ſubjoin this General Reflexion upon the whole Diſcourſe, that *Infinites* of all Kinds, as to their poſitive Nature, are equally

qually above our Comprehenſion, it is the ſame thing as to us, whether they be ſimply *infinite*, or infinitely *infinite*, their eſſential and poſitive Proprieties are equally beyond our reach, as the *fixt Stars* ſeem to our Eyes, as it were, all ſtuck into the ſame *Concave Sphere*, tho' they be at various, if not infinitely different Diſtances from us. And therefore in our Inquiries about the Nature and Proprieties of things, we ought to paſs over all thoſe in which Infinity is concern'd, as being without our *Sphere*, and not belonging to our Province: where Finity is only concern'd, there we may labour, and hope for Succeſs, God Almighty having given us Capacities, adequate for ſuch *Reſerches*; but where ever *Infinity* in its *abſolute* Nature, and *poſitive* Qualities, is involv'd, there we have nothing to do, but to leave the Matter as we find it; and this Reflexion may be of uſe to us, in quieting our Minds, about the Difficulties ariſing in the conception of thoſe things, where the poſitive Nature of Infinites, are neceſſary to be underſtood; and ſuch are ſeveral Subjects, both of Philoſophy and Religion. God Almighty cannot be ſuppos'd to work Contradictions, and if we be Creatures, we muſt partake of the eſſential Natures of ſuch, and by conſequence, be of finite Capacities and Faculties, and ſo it is impoſſible even for him to make us underſtand the poſitive Nature and Qualities of *Infinites*. And no wiſe Man will attempt what it's impoſſible he ſhould obtain, nor be diſquieted at what he can never help.

FINIS.